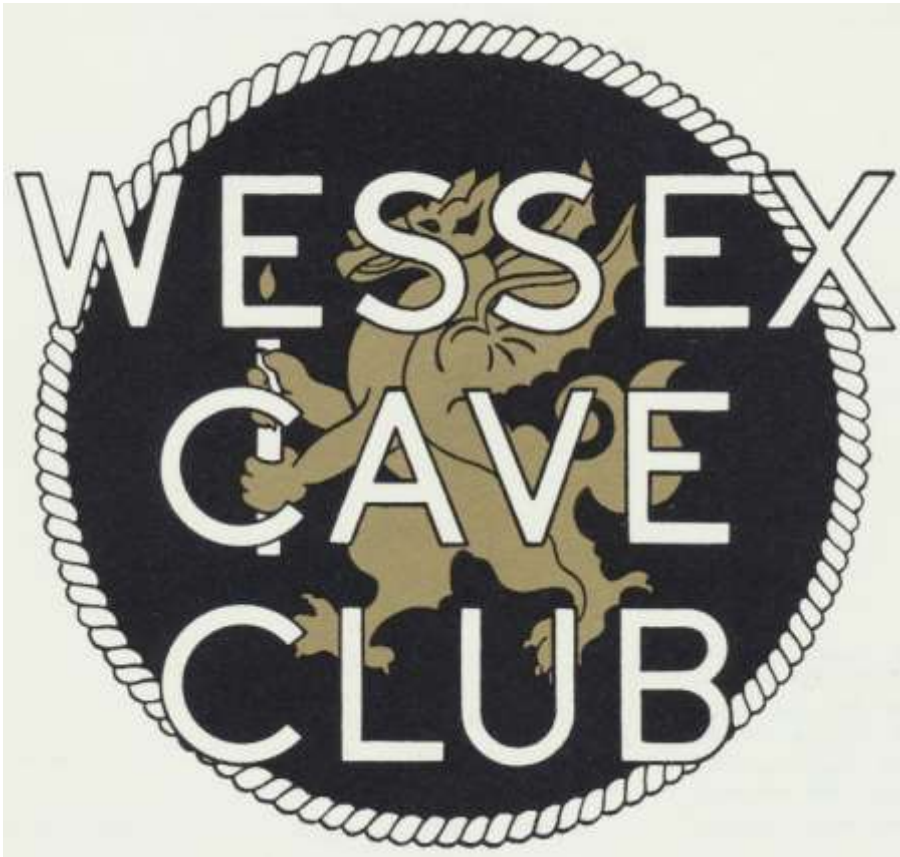
WESSEX
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WESSEX CAVE CLUB

Journal No.89, Vol.7. April 1963

CLUB NEWS

Journal Production

Nick Hart has recently been appointed "Journal Production Manager". His responsibilities are to duplicate, collate, address, envelope and post future issues of the Journal, and he is likely to be calling on Bristol members for assistance in this work which, when done by a team, is not a chore. The last Journal was produced by Nick and those who helped with the latter stages said that they had enjoyed the evening. Offers of help will be most welcome from persons willing to assist with the various stages at Long Ashton. Please contact Nick at 80 Ridgeway Road, Long Ashton, Bristol.

New Members

We have great pleasure in welcoming the following new members to the Club:-

Elected 3.3.63: A. Armstrong, 25 Disraeli Road, Putney, London S.W.15.
W.J. Hanson, New House Farm, Coxley, Nr.Wells, Somerset.
B.D. Price, The Lord Weymouth School, Warminster, Wilts.
C. Pickstone, Icknield Way House, A.E.R.E., Harwell, Berks.
P.R. Trebess, Icknield Way House, A.E.R.E., Harwell, Berks.
R.I. Walker, 203 Redland Road, Redland, Bristol 6.

Club Ties

The first batch of ties will be available before Easter. The pattern chosen by the Committee consists of a printed repetitive design showing the Wessex Dragon approximately ½" high in gold, holding a white candle with red flame on a black terylene tie. It was found impossible to obtain a woven design on the tie in reasonable quantities at a reasonable price. However, the printed design is guaranteed washable and hard wearing. Price 15/6 post free from the Secretary. All those who have ordered (28) please send remittance as soon as possible. Requests for ties not previously ordered will be dealt with in strict order of receipt of payment. Club cloth badges available from either the Hut Warden direct or from the Secretary, 5/- post free. Car Badge enquiries to C.J. Hawkes, 147 Evington Lane, Leicester.

Tackle

A gift by Eric Hensler of a 36ft. aluminium alloy Maypole with all joints and fixtures has further added to the diversity of caving equipment available to members on request from the Tackle Warden. The pole, in 4ft. sections, is easily erected, the joints are cave proof and it should prove to be a valuable asset. Thank you, Eric.

A quantity of heavy duty wire belays with eye splices and C links has been provided for Club use. Owing to the ease with which these are lost only basic requirements will be kept at Hillgrove in the Tackle Hut; the remainder can be obtained on request to the Tackle Warden. Members are reminded that Committee approval is normally required before Club tackle can be taken away from Mendip. Those intending to borrow ropes, ladders, belays, etc., for such trips

must, therefore, give plenty of warning of their intentions, particularly if the period is at all prolonged or the requirements large.

Assistant Hut Warden
Nick Hart has been appointed to this post by the Committee, to help George Pointing with his ever increasing responsibilities, and to take over in George's rare absences from Hillgrove at weekends.

Carbide
The Club has obtained a large quantity of good quality Carbide for resale to members at 9d per pound. Please apply to the Hut Warden or Assistant Hut Warden and provide tins if possible. Only available at Hillgrove

Boxes at Hillgrove
A limited number of storage boxes intended for non-perishable foods and dry caving kit are to be provided for members' use at Hillgrove. Application should be made in writing to C.H.Kenney, Tudor Cottage, Beryl Lane, Wells, Somerset, within one week of receipt of this Journal. Allocation of boxes will be dealt with by a sub-committee who will consider the merits of each applicationi members will be encouraged where practicable to share boxes, and must provide their own padlock and keys. Rental 5/- per annum.

Secretary's Annual Holiday
The attention of members is drawn to the fact that the Secretary will be in Ireland again this year from 28th May until 19th June and therefore any urgent correspondence during these weeks should be addressed to the Assistant Secretary, Dave Causer, 19 Kenmore Crescent, Filton Park, Bristol 7. Tel. 692864.

CLUB MEETS

28th April G.B. Cave. Names to Roy Staynings, 8 Fanshawe Road, Hengrove, Bristol. Meet at Cave Entrance, ready changed, 12.00 noon. Members using the Long Barn for changing must not forget to pay Mr. Young l/- in addition to giving the leader the usual tackle fee levied by the U.B.S.S.

4th May Club Trip Abroad, 1964. The President hopes to be able to show slides and give a short talk about the two previous Club trips abroad, in 1948 to the International Speleological Congress and in 1949 a visit to the caving areas of France. 7.30 p.m. at Hillgrove. This will be followed by a discussion on the proposed Club Meet Abroad in 1964. Any and every member who is at all interested in the idea should make a point of attending so as to be able to help decide in principle what sort of activities the majority are interested in, and what transport and time of year are most convenient. We realise it is only April 1963, but if such a trip is to be successful advance planning is essential.

4th/5th May Cow Hole. Small party required to regain ground lost during the winter recess. Names to Alan Surrall, 25 Beverley Court Road, Quinton, Birmingham 32.

8th May Public Lecture by M. Michel Siffre on Wednesday, 8th May, at 7.15 in the Geography Lecture Theatre, The University, Bristol. M. Siffre will be speaking in English on his experiences during his two months' stay alone down a cave in France last year.

18th May Trans-African Expedition - 1962 by D.J. Causer. The previous talk (see page 143 of Journal No. 88) had at the last moment to be cancelled owing to Dave's illness and an alternative programme of expedition films was hastily arranged. Dave will try again at Priddy Village Hall, 7 p.m. A cordial invitation is extended once again to members of any other Caving Clubs who wish to attend.

18th/l9th May Cow Hole. Alan Surrall hopes to break new ground and a large party would be very welcome. Details from Alan at above address in Birmingham.

25th/26th May South Wales. Leader George Pointing, 10 Green Lane, Avonmouth, Bristol. Suggested caves: Saturday, Ogof Ffynnon Ddu; Sunday, Porth- yr-Ogof and/or other caves in the area. It is hoped to arrange accommodation at the S.W.C.C. headquarters.

lst/2nd/3rd June Whitsun - Cow Hole. All those wishing to avoid traffic jams are invited to join Alan Surrall for a camp and a leisurely dig at Cow Hole over the Bank Holiday.

9th and/or 16th June St. Cuthberts. Leader Jim Giles - names to P. Davies, "Morley", Silver Street, Nailsea, Bristol. Meet at Hillgrove 11 a.m.

29th June Stoke Lane. Names to Howard Kenney, Tudor Cottage, Beryl Lane, Wells, Somerset. Meet at the barn 3.00 p.m.

13th/l4-th July Burrington Weekend (Caving, Walking, Eating). Details from Rodney Hobbis, Warren Lodge, Long Ashton, Bristol.

3rd/4th/5th August Bank Holiday in Devon. Details to be announced later.

24th/25th August A further trip to Agen Allwedd is planned. Details to be announced later.

Hon. Secretary: P. Davies, "Morley", Silver Street, Nailsea, Bristol.
Phone: Nailsea 9.
Hon. Asst. Secretary: D.J. Causer, 19 Kenmore Crescent, Filton Park, Bristol 7.
Phone: Bristol 692864
Hon. Treasurer: Mrs. B.M. Willis, 3 Derwent Lodge, St.Philip's Avenue, Worcester Park, Surrey.
Editor: C.J. Hawkes: 14-7 Evington Lane, Leicester.
Hut Bookings: E.R. Hanwell, 8 Hooper Avenue, Wells, Somerset.

THE ACCURACY OF A CAVE SURVEY

Denis Warburton

With a number of cave surveys being published in 1962, every major Mendip cave and many of the smaller ones have now been surveyed, most of them to a fairly high standard of accuracy. The main purpose of this article is to discuss, rather comprehensively, a number of points regarding the accuracy of surveys, with particular emphasis on Mendip caves. I should like to stress the word "discuss"; this is not an attempt to set out a rigid procedure, or for that matter any procedure at all, but rather to put forward some ideas of my own. These ideas have emerged from more than a decade of surveying underground.

I should also like to emphasise that my surveying colleagues in the W.C.C. do not necessarily agree with some of my conclusions, and I hope that any disagreements will be freely and fully ventilated in the pages of this Journal. This long, and in places rather controversial, article may seem to many readers to be somewhat too technical, but if they will bear with me for a few pages it will be seen that it is not as difficult as all that. Should some of the older members have trouble with the calculations, their "eleven-plus" children will certainly come to their help.

The system for indicating the accuracy of a cave survey is now based almost exclusively on the recommendations of the Cave Research Group. Their publication "Cave Survey" has become the cave surveyor's Bible since it was first published in 1950, and almost all the Mendip surveys have been given a C.R.G. grading. The only major exception is the survey of G.B. Gave and the (valid) reasons for not giving this a grading are detailed in the accompanying publication.

It will be helpful at this point if the grades are detailed.

GRADE 1 Rough diagram from memory - not to scale.

GRADE 2 Sketch plans, roughly to scale, no instruments used; distances and directions estimated.

GRADE 3 Rough survey. Small pocket compass graduated to 10 degrees; lengths by marked cord or by stick of known length.

GRADE 4 Prismatic compass graduated in single degrees (compass error not known), measuring tape or marked cord.

GRADE 5 Calibrated prismatic compass, clinometer, metallic or steel tape, bearings to nearest degree.

GRADE 6 Calibrated prismatic compass or Miner's Dial mounted on tripods; clinometer with tripod; distances by chain or steel tape, or tacheometry.

GRADE 7 Theodolites for bearings and slopes| distances by steel tape, chain or by tacheometry. Or by any more accurate method which may be devised in the future.

Grades 1 and 2 do not concern us here; they are of considerable value in writing up Club Logs and discussing the latest discoveries (a very useful Grade 1 may be drawn on a polished bar using only the right forefinger and a splash of bitter), but the present article is to consider only surveys with measurements. Grade 2, it is worth noting, may give quite a reliable sketch survey in many Mendip caves. Although the direction is only estimated, the steeply dipping limestone over much of the area enables the bearing to be arrived at with considerable precision - for instance, over much of Eastwater the passage direction can be determined to within 20 degrees or better, merely by looking at the dip of the roof.

With Grade 3 we come to the first of the measured grades. No fixed positions are normally used in this survey, and as well as marked cord a "body's length" is often used as a measure of distance, especially in constricted passages. Many people consider this grade as quite useless for a survey - later on we shall test the validity of this idea.

The next grade has for its bearing "prismatic compass graduated in single degrees" and it is stated that the compass error is not known. Marked cord may still be used for the distance, and most important of all, there is no means of measuring the vertical component. The writer feels that this grade is not a logical bridge between Grades 3 and 5, in that the accuracy of direction has been improved by a factor of about 10 over Grade 3, while the distance and the vertical component are not affected. On many occasions in the last few years there have been surveys produced which are considered by the surveyor to be only of Grade 4, even though a clinometer has been used. The fact that so many Mendip caves have steeply descending passages makes some form of inclination measurement almost essential, even if it is only a simple protractor and a plumb line.

The accuracy of the bearing also seems to be greater than the other measurements warrant, and it would seem that a compass (not necessarily prismatic) reading to the nearest 2-3 degrees would best fit the case. With this in mind, I have modified the requirements for Grade 4 in the present article, to read (with apologies to the C.R.G.):-

GRADE 4 Hand compass reading to 2-3 degrees, simple clinometer (or angles of dip estimated - this only comes with considerable practice) measuring tape or marked cord.

With reference to "marked cord" it should be noted that a non-compensatory error can be introduced here. Cords, and to a lesser extent cloth tapes, are liable to alter considerably in length when wet or when subject to an excessive pull, and this error is not apparent on a closure. If either of these articles is used it should be checked for length at the time the survey is made, preferably against a steel tape or similar standard. This is seldom convenient, and tends to destroy the idea of Grade 3 as a rapid preliminary survey, so that any errors from this source

must generally be accepted. The alternative is to use a steel tape for the survey, this is only slightly less convenient than a cord.

With Grade 5 we come to the first of the 'precision' gradings, in which all the three readings are as accurate as the instruments permit. The Grade states "bearings to the nearest degree," but with most if not all prismatic compasses the limit of reading the dial is ½ degree. The reading angle of the clinometer is not stated; with a number of the popular types used for cave survey the reading limit is at least as good as ½ degree, and in some types may be considerably better.

Some little discussion is warranted here on the 'calibration' of a compass. There are three possible causes of error in a compass bearing. The first is that the engravings of the card or dial may not be exact, and that some of the scale intervals will be less and some more than a degree. In theory this could lead to an accumulated error in certain bearings. This is quite a difficult thing to check without very precise equipment not normally available to amateurs, and it can be accepted that it does not normally occur in any good compass to the extent that would noticeably affect a cave survey. Most compasses that are used for this work are obtained on the 'ex-Government' market and these instruments are made to a very much higher standard than necessary. We can neglect this error.

Another error, and one that is more likely to be found, is caused by the magnet (or set of magnets) not being correctly oriented with respect to the card. This can be shown by taking the instrument to a point from which several bearings can be taken and related to the O.S. map. One must, of course, ensure that there is no possibility of any magnetic material nearby affecting the result; one or two trials at different points will soon enable this error to be ascertained. As a matter of interest it may be mentioned that the writer has never encountered this error in any of the compasses used by the Survey Group - even in one rescued from a pile of brass scrap! It can occur, however, and it can be very serious on a Grade 4 survey, as this grade does not call for a calibrated compass.

An excellent example of an error probably due to this cause can be seen if the surveys of August Hole by Stride (1948, accuracy not specified) and Rennie (1962, Grade 6) are compared. When allowance has been made for scale and passage detail, it will be seen that the two plans are very close indeed in distance and in the relation of the various extensions and twists of the passage. The linear distance from the entrance to the commencement of the final rift is almost identical on the two surveys, but the bearings differ by 40 degrees! As the compass used on the Grade 6 survey must have been calibrated to claim Grade 6, then the compass used by Stride must have had a constant error of 40 degrees. This, of course, is another of the non-compensatory errors that does not show up in a closure. Even for a low grade survey it is worth doing a rough check on the calibration, preferably not in a limestone region, as there is often a different magnetic field over limestone to that found elsewhere.

The correction that springs to mind most readily when the 'calibration' of a compass is mentioned is the correction for the local magnetic anomaly. Although it is very easy to find the local magnetic field "from a point near the cave entrance", this is one of the traps into which

it is very easy to fall. The snag is that if we do just that, we are relating the whole of our survey to one single position line which may well be affected by an extraneous field quite apart from the one we are trying to correct. To give an extreme example: near our cave entrance is a wall junction marked on the 6" map, and a mile or so away is a church spire which is also marked. We take our readings before each survey trip, and arrive at a local field of 2.5 degrees (a quite common figure). On the fourth trip we get a reading of 1 degree, a very low figure. Searching for the reason we eventually find that the iron gate at the corner of the field is open, whereas on the previous occasion it was shut. Experiment proves that we can get any field we like between 1 and 5 degrees by swinging on the gate! The solution is not always so obvious, but the results may well be as inaccurate as in this example.

If we are to correct for the local magnetic anomaly in a logical way we must check it at several points in the area covered by the cave - say half a dozen points. If the first three readings give the same figure we may be reasonably certain that there is no need to check further. In extreme cases it may even be necessary to prepare a magnetic map of the area of the cave, with the further headache that one is never certain that the deviations penetrate to the depth of the cave. It is not always easy to find a number of well marked position lines in some areas, but unless we do it we are liable to introduce an error of comparable magnitude to the one we are correcting.

Let us assume for a moment that we are not correcting it, and that we are plotting our survey using the figure for magnetic deviation given on the O.S. map. In the limestone area of Mendip generally we shall be in error by 1-3 degrees. If we have only one entrance, or two linked by our own survey on the surface, there will be no way of telling that our survey is not correct - it will merely have been swung bodily round by 1-3 degrees from our O.S. datum point at the entrance. In short, it will not matter, except to a purist. If we are hoping to prove the existence of an alternative entrance, then we must survey above ground to that entrance using our underground survey instruments, rather than plotting off the O.S. map.

The only time that the magnetic anomaly can affect us is when we use a mixture of magnetic bearings and O.S. position lines without relating the two. This is quite rare in cave surveys - the only instance that springs readily to mind on Mendip is the location of the Priddy Green dig in relation to Swildons Hole (I may be wrong here, but I imagine that the location of the P.G. dig has been taken off the O.S. map rather than by a laborious traverse from the Swildons entrance). If we want to do the type of survey that calls for accurate surface to underground linkages we must determine the local magnetic anomaly properly - if not, we should not determine it at all.

The clinometer may need calibrating as well as the compass. Once more the error of engraving the scale may be neglected, but the zero should be checked, as this may be found to be as much as two degrees out. This has a relatively large effect in a level passage such as those in Stoke Lane I, and even more so if all the measurements are taken in the one direction. This error is reduced considerably by the use of the 'leap-frog' technique mentioned later, and eliminated completely if back bearings are taken.

The distance measurement of Grade 5 is given by steel tape, and this does not call for much comment. In several tapes used by the writer (they have a relatively short life in some caves) a considerable magnetic disturbance could be caused when the tape was extended near the compass, but none when it was coiled. If this is found to be the case it is important to make a rule that the compass shall only be read when the tape is rolled. A tape that has been placed on the market only recently is made of a material called Fibron, and this may prove to be the ideal measure for cave surveying (at least if the maker's claims can be upheld). It is claimed not to stretch or shrink, to be unaffected by mud and water, and to be uncreaseable. It is also cheaper than conventional tapes.

Grade 6 differs from Grade 5 only in the fact that the instruments are tripod mounted instead of being hand-held. This, of course, increases the reading accuracy somewhat, but the most noticeable effect of using tripods is the considerable reduction of position error. A point to bear in mind is that if a mirror clinometer is used, then from its very nature it cannot be mounted directly on a tripod, but it will be found that the use of this instrument in the hand does not introduce any appreciable error if the tripod platform is used as a rear sight. The essential point of this grade is that the instruments are read from a stable platform, and this need not necessarily be a tripod. It can be a rock ledge, a cairn built up for the purpose, or even the box in which the instruments are carried.

Grade 7 is a somewhat controversial one. The original wording is quite unambiguous, "theodolite for bearing and slopes". No doubt the intention of the author was to ensure instrumentation that would give the most accurate possible measurements, and a professional theodolite would, of course, give results far superior to magnetic instruments in suitable passages. However, on some cave surveys in recent years there has been a tendency to lash up a hybrid instrument from an ex W.D. astro-compass, and refer to this with supreme optimism, as a theodolite.

Now a theodolite traverse differs radically from a magnetic one in its general properties. In the latter, each single bearing is related to a fixed position line (the earth's magnetic field) and an error in one leg does not affect the rest of the survey by more than the amount of that error. In other words, if our first leg is inaccurate by, say, 5 feet, then the rest of the survey points will be affected by that error to the extent of 5 feet only. A theodolite traverse, on the other hand, has the property that each bearing is related, not to a fixed position line, but to the direction of the previous bearing. It can easily be shown that the possible errors with this method of surveying can soon become very great unless the bearings are taken with great precision. This cannot be done with home-made theodolites, and a non-closed traverse can soon become quite useless. An even bigger snag with a theodolite traverse lies in the fact that gross errors can have a disastrous effect. To give an example, a reading mistake of 20 degrees in the first angle of a Grade 7 survey (not at all impossible under difficult conditions) will reduce the whole survey to the equivalent accuracy of a Grade 3, even if no other mistakes at all are made. The Survey Group are at the moment working on a Grade 7 survey using a professional theodolite, but there will be many additional precautions taken that are only possible under ideal conditions.

There are two ways of avoiding the difficulties. The first is to use the instrument in the same way that a theodolite is used in O.S. work - for triangulation instead of traverse. The separate triangles can be summed on the spot and any gross errors corrected immediately. Even in this case a further problem remains; that of relating the triangulation network to a position line outside the cave. Unless one is very lucky with fixed positions this can all too easily lead to a Grade 7 survey being linked to surface detail with a much less accurate position line. Given a suitable type of cave an astro-compass is reliable enough for triangulation, and a very good example of its use is in the survey of G.B. Cave. The other way of avoiding the difficulties is simply to do a proper Grade 7 - using a theodolite! Ideally this should be the type that is used for mine surveys; it should be capable of reading to about 1 minute of arc or better and it should be easy to read. A suitable instrument for the purpose would be the Wild T1A and ancillary equipment, at a price of £380!

Of course, a low accuracy survey can be made with a converted astro-compass even on a traverse, but surely the whole point of a Grade 7 survey is that it should be more accurate than a Grade 6? The anomaly here may be seen when the survey of St. Cuthbert's Swallet is considered. A "Grade 7" survey with an astro-compass failed to close by "several feet and eleven degrees" in 141 feet, a figure one would expect to better on a Grade 5 survey.

If there are disturbing magnetic effects in a passage, due to ironwork or local magnetic bodies, then such a survey may have to be used to get a line through at all, but it should not be called Grade 7. For the calculations made later in this article the writer has taken advantage of the last part of the definition of Grade 7, "or by any more accurate method which may be devised..." This method simply consists of the general instrumentation of Grade 6, modified in such a way as to reduce the error to a minimum, by the use of special tripods to reduce position error, by 'leap-frogging', and by reading all the instruments to the closest possible limits. A further refinement in this "Grade 7" is the obtaining of closures in each passage by the simple method of surveying it twice! In actual cave survey practice this would probably be given a grading of 6 - it is included here to give an idea of the limits of accuracy of a magnetic traverse. It should be emphasised that this is only a makeshift Grade 7; if a good theodolite is used with the proper precautions, a true Grade 7 will be more accurate than a Grade 6 by a factor approaching 10 rather than 2. However, as the calculation of error for a theodolite traverse is entirely different from a magnetic traverse we shall not consider it here.

An important thing to notice is that the gradings do not indicate the absolute accuracy of the survey, but merely detail the instruments used. This was probably considered to be unavoidable owing to the fact that both caves and cave surveyors vary enormously and the only actual figure given in "Cave Survey" is the statement that the accuracy of a Grade 4 survey cannot be expected to be better than 5%. The grades obviously increase in accuracy from 1 to 7, but it is not at all clear how, for instance, a Grade 4 survey would compare with a Grade 6 survey of the same passage.

In talking to various members recently, I have found some confusion as to the definition of the accuracy of a survey, and also on the relative merits of different techniques of surveying. From time to time in various publications there have been criticisms of the C.R.G. gradings, and there have been several modifications proposed. In some surveys the grading has been given as 4-5, or 3½, and these modifications, without any way of backing them up with actual figures, cannot give a very helpful picture. One suggested method of approach was given by Ellis in "Belfry Bulletin" No. 169, which gave gradings to individual instruments; these gradings being then added to arrive at the overall figure. This approach is very practical and gives a much more flexible system than the original scheme, but it still does not answer some important questions, namely - how accurate is (say) a Grade 5 survey likely to be, and how much more accurate would it be if we surveyed the same cave to Grade 6? How far out would that stream passage be if we only surveyed it to Grade 4? We need an answer in feet, or degrees, or percentages, not in vague generalities.

Unfortunately, we must here start to delve into the methods and formulae of statistics, but we shall not delve too deeply, and the reader whose mathematics has long since dissolved in a cloud of rust need not worry. The next few paragraphs can be (and probably will be) skipped over, and the conclusions alone considered. Experienced statisticians will notice that certain somewhat loosely worded statements are made - this is done deliberately to avoid turning the article into a mathematical exposition. The writer has neither the wish nor the ability to be considered an authority on statistics.

It has become accepted practice to talk about an accuracy of so many per-cent, and this practice will be adopted in the discussion that follows. It should also be made clear that when we talk about accuracy in the majority of cave surveys we really mean precision, as we can only state the accuracy when a special type of closed circuit occurs; this is an academic point that we can afford to ignore from now on.

When we say that a survey of a passage 500 feet long has an accuracy of 2%, we mean that a point at the end of the passage has a "probable error" of 2% of 500 feet; that is, it may be 10 feet from where our plan shows it to be. The point about using percentages instead of quoting the "probable error" in feet, is that surveys of widely varying length may be directly compared. A "probable error" of 10 feet does not mean that the point will <u>always</u> be within 10 feet of its true position, but rather that it will lie within the 10 feet a certain proportion of the time, say 95%. This means that one can say that the point will be within the 2% limit 19 times out of 20, but that there will be occasions, namely 1 in 20, when the error of the survey will exceed the expected 2%.

There is a measure in statistics known as the "standard deviation". This can be derived from sets of actual measurements and in certain cases it may be calculated theoretically.

Its exact meaning and the way of calculating it need not concern us here - what matters is that we can use it to come to certain conclusions about our measurements, either singly or in sets which make up a survey. In the case just quoted, the error was said to lie within 2% on 19 occasions out of 20. From this the standard deviation can be calculated directly - it happens to be almost exactly 1%. And now we are in a position to say this about our measurements:-

They are in error by more than 1% once in 3 times
They are in error by more than 2% once in 20 times
They are in error by more than 3% once in 400 times
They are in error by more than 4% once in 16,000 times

and so on.

In general, although it is possible that our error will reach a very large value - say 10% in this case - it is extremely unlikely.

In the previous paragraph we have deduced the standard deviation from the stated fact that the error was expected to lie within 2% 19 times out of 20. In an actual cave survey, of course, the reverse applies; we find the standard deviation first, from the measurements (if we have sufficient of the right type), from past experience or from theory. Having the standard deviation we can then make predictions about the accuracy of the parts of the survey that do not lie on closed circuits.

All the predictions based on this standard deviation assume that the errors concerned are random ones, or errors of the compensatory type as they are sometimes called. To put it rather simply we can say that we are accounting for errors and not mistakes! Errors of the non-compensatory type are not included in this analysis, for the simple reason that in small sets of measurements such as we deal with in cave surveys they are not amenable to analysis. This type of error also includes mistakes such as reading 216 degrees for a bearing of 261 degrees, or booking a length as 25 feet instead of 35 feet.

The question of random errors compared with constant bias is an important one. In the calculations that follow it may be thought that too much emphasis has been placed on random errors and not enough on systematic bias. This has been done deliberately - the writer feels that as far as practical work is concerned systematic errors are not as important as sometimes thought. Without going into too much detail, if there is a systematic bias in the measurement of distance there will be an alteration of scale and if there is a systematic bias in the measurement of direction there will be an alteration of orientation. In neither case will the shape of the survey be affected. Also the systematic errors are well known and can be easily eliminated; not so the random ones.

We can now come to cave measurements! If we stand at a known point in a cave, Point A, and we want to know the location of another point, B, which we can see, we need to make three measurements:

1) The magnetic bearing from A to B; i.e. relating the bearing to a known position line on the surface (the earth's magnetic field).

2) The angle of inclination from A to B; i.e. relating the direction in a vertical plane to a known position line (the vertical one due to gravity).
3) The distance from A to B.

These three measurements are necessary and sufficient to obtain the correct location of point B. It is, of course, possible to cover (2) by standard levelling techniques, but this is not common. Caves are not as well planned as mines!

There are now four sources of error which must be considered:

a) Compass error. Even when the compass is set and calibrated, there remain residual errors due to sighting difficulties, reading uncertainties and minor local magnetic deviations.
b) Clinometer error. This is mainly due to sighting difficulties and reading uncertainties.
c) Tape error. This is mainly due to incorrect tension on the tape and faulty judgement of interpolated distances. The fact that the end of the tape may not be exactly on the survey point or the target is not included in tape error, but in position error. The tape error should be the smallest and most predictable of the errors.
d) Position error. This is probably the most important and least recognised source of error. The most usual way of surveying a passage is to set up the instruments at A, take the readings from A to B, then move to B and sight forwards again to the next point, C, and so on. The position error arises from the fact that the instruments will not be stationed exactly on the same point as the target lamp for the previous sighting. With lower grades of survey and with difficult caving conditions this error might be expected to assume major proportions, and its reduction offers one of the simplest ways of increasing the accuracy of the survey.

The compass and clinometer errors are independent of the length of the survey leg (remember we are considering percentages and not absolute values); for small errors they amount to about 1¾% per degree, and for larger amounts are easily looked up in a table of sines. The tape error is inversely proportional to the distance; that is, it is of greater importance on short legs than on long (an error of 3 inches in a leg of 5 feet is 5%but in a leg of 50 feet is only ½%. Similarly, the position error is more important on short legs than on long.

We now require to assess the cumulative effect of all these errors, and to do this without considering each survey separately we must simplify the problem slightly. Purists may object to this, but our simplifications do not affect the arguments to any great extent. First we shall assume that our cave survey has all its legs of the same length, and secondly that we may sum our errors vectorially.

The figures in Table 1 show the “reading limits” adopted for the five grades of survey, and Table 2 the standard deviations taken from these, expressed as percentages. It will be noted that for the top three grades the standard deviation is taken as three times the “reading limit”, but for the lower grades only l½ - 2 times. This is because in the lower grades one is not working to the limits set by the optical and mechanical parts of the instruments, but rather to the limits of one’s own care and patience.

TABLE 1
"Reading Limits" for various. Grades

	3	4	5	6	"7"	
Compass	10	2	½	½	0.2	degrees
Clinometer	-	2	½	0.2	0.2	degrees
Tape	24-36	3	1	½	¼	inches
Position	12	8	4	½	¼	inches

TABLE 2
Standard deviations of measurements expressed as percentages

	3	4	5	6	"7"
Compass	25.8	8.7	2.62	2.62	1.07
Clinometer	-	7.0	2.62	1.05	1.05
Tape 10 ft.	40.0	5.0	2.50	1.25	0.63
Tape 20 ft.	20.0	2.5	1.25	0.63	0.32
Tape 50 ft.	8.0	1.0	0.50	0.25	0.13
Tape 100 ft.	4.0	0.5	0.25	0.13	0.06
Position 10 ft.	20.0	10.0	5.00	1.25	0.63
Position 20 ft.	10.0	5.0	2.50	0.63	0.32
Position 50 ft.	4.0	2.0	1.0	0.25	0.13
Position 100 ft.	2.0	1.0	-.50	0.13	0.06

It is an extremely difficult thing to read a high-precision compass to 0.2 degrees, even under the best conditions, whereas a compass with 10 degree intervals as required for Grade 3 can often be read much more accurately with little effort. The figures in Tables 1 and 2 have been derived from a mixture of theory, experiment and experience on actual cave surveys. They are open to criticism as to their exact values.

Table 2 also gives the standard deviations of the tape and position errors expressed as a percentage of different lengths of leg. 10 and 20 feet as average legs are fairly typical of many Mendip caves, 50 feet might be reached in some of the larger ones, while 100 feet is included as an extreme value to facilitate plotting the graphs. We now calculate the overall error for each grade, expressed as a percentage error for different lengths of leg. Notice also here that the overall error is the three-dimensional one - the plan error will be rather less. These figures, in graph form, comprise Fig. l.

Now a cave passage of, say, 500 feet in length would have 50 legs of 10 feet, but only 5 legs of 100 feet, and the error is calculated by multiplying the error per leg by the square root of the number of legs. Figs. 2-6 show the result of this operation - again as a percentage, this time of the full traverse.

The percentage error per leg is least for a long leg owing to the reduced effect of tape and position errors, but this is more than offset by the compensatory effect due to a large number of legs. Many would consider that in an actual survey this point should not be pressed too far. It is possible that a passage which gave an average leg of 10 feet would be far more difficult to survey than one which gave an average leg of 100 feet, and this would tend to narrow the gap. We shall return to this point later.

We can derive intermediate values from these graphs simply by plotting other graphs of certain of the quantities. For instance, suppose we have a Grade 5 survey of a 350 feet long passage, the average leg being 16 feet. From the appropriate graph, Fig. 4, we can read off the accuracies for the four lengths of traverse. Then plotting the four figures obtained against the total lengths (Fig.7) we can find the accuracy figure for a 350 feet traverse, which turns out to be 1.02%. In this way we can check the expected accuracy of all parts of our survey.

The preceding pages may seem to many practical cavers to be an example of theory run wild, and when the writer first began to consider the problem some years ago it seemed that such a mass of theoretical considerations could have little or no real value. However, detailed records had been kept of surveys over many years and each closure was subjected to the mathematical treatment. This process has now been followed with nearly thirty closures. This is the acid test. A theory has been derived from reasoning and experimental work - it can now be seen if its predictions have any real validity by testing them against actual field work.

The results are shown in Table 3. This shows the actual percentage error obtained from closures in the caves given, together with a 'theory' column which is the calculated figure of 2 S.D.'s modified by a factor which allows the use of the more generally quoted plan error instead of the 3-dimensional error of the theory.

It can be seen that in general our theory gives quite acceptable results. True, there are five misclosures greater than the theoretical instead of the one or two that one would expect, but three of those five are only just over the limit, only Nos. 5 and 27 being much out. Many interesting things can be shown by further work on these figures, but for now we shall only refer to one or two. Surveys of Grade 6 conform most closely to our theory, Grade 5 is rather less accurate than we would predict and Grade 3 is very much more accurate.

The last column in the table is the ratio of the actual error to the theoretical error. Those readers who have a leaning towards statistics and who have followed the argument this far are invited to plot the distribution of the results using these figures.

It might be considered that the actual grading could best be given by a percentage error (weighted for circuit and length of leg), but this is not practicable. To do it in any reliable manner would involve obtaining at least half a dozen closures (natural or constructed) and even then there would be a doubt. The most useful way of indicating the accuracy is to specify the instruments used with any pertinent details, and also the full closure figures. Anyone sufficiently interested can derive the information he wants from these figures.

FIG 1

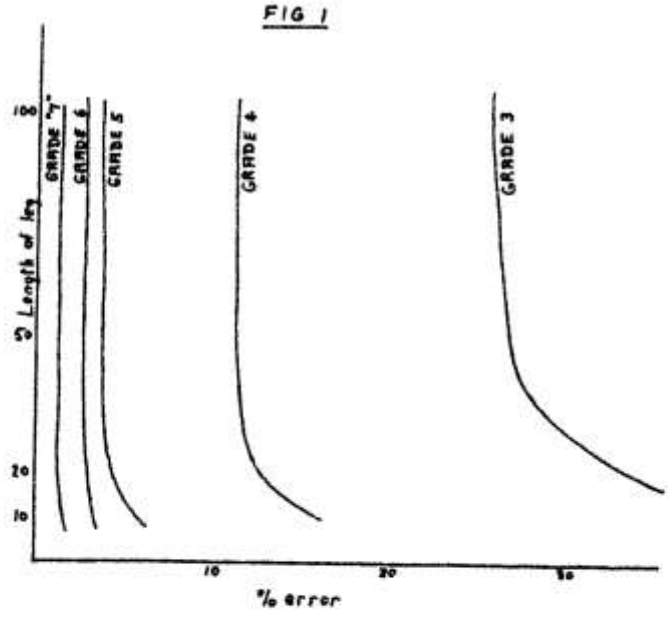


FIG 2

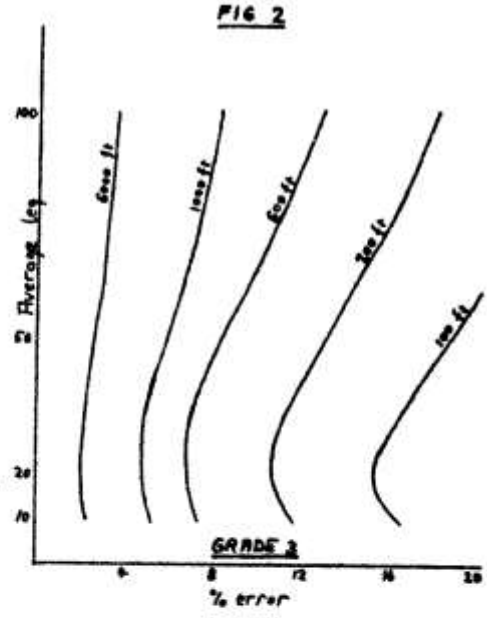


FIG 3

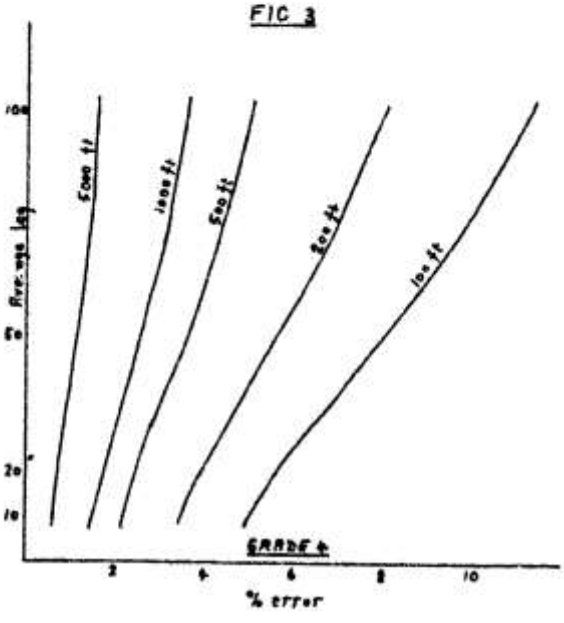


FIG 4

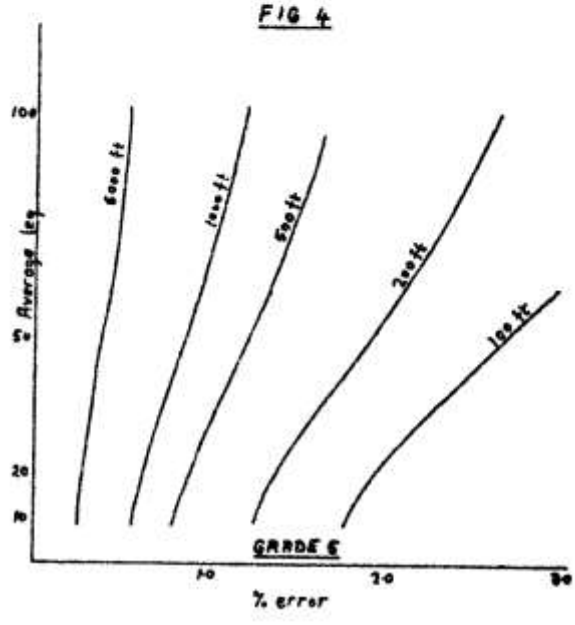


FIG 5

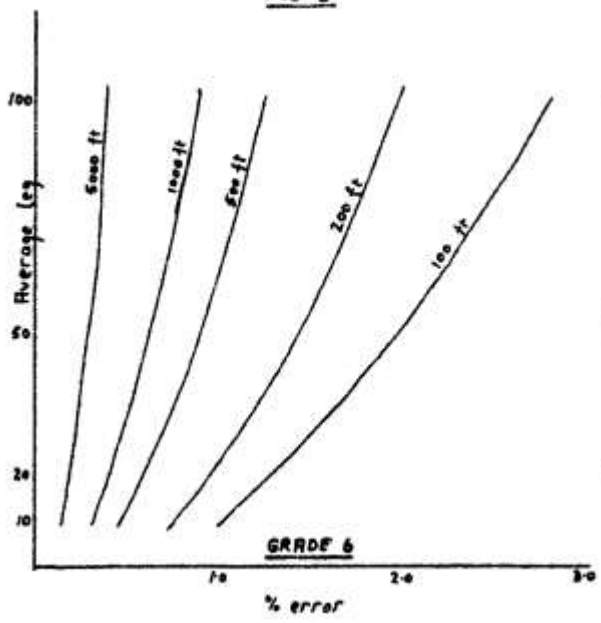


FIG 6

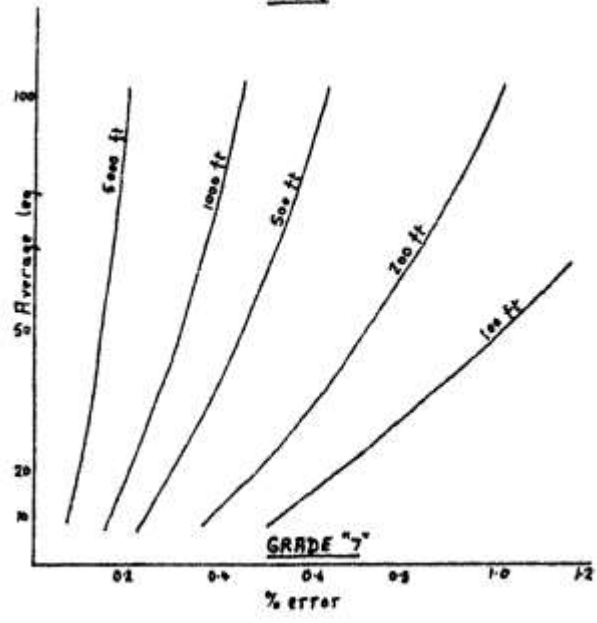


FIG 7

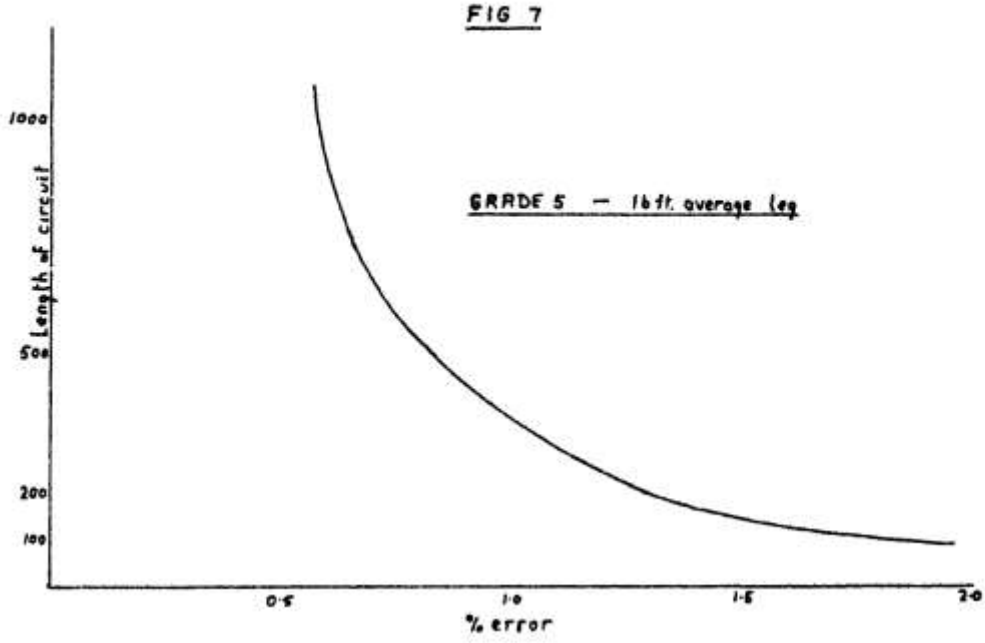


TABLE 3

No.	Cave	Length ft.	Ave. leg ft.	Grade	% mis-closure	Theory	Ratio
Surveys of W.C.C. Survey Group							
1	Eastwater	542	13	6	.03	.76	.08
2	"	288	15	6	.41	1.10	.74
3	"	259	11	6	.42	1.07	.78
4	"	110	12	5	2.96	2.96	2.00
5	"	675	18	5	1.49	1.24	2.40
6	"	680	18	5	.92	1.24	1.48
7	"	285	11	4	2.58	5.13	1.00
8	"	118	17	4	3.11	8.66	.72
9	Hilliers	302	13	5	1.78	1.82	1.96
10	Stoke Lane	340	15	5	1.30	1.76	1.48
11	Fernhill	58	10	5	3.44	3.81	1.80
12	Pate Hole	348	29	5½	1.79	1.79	2.00
13	"	504	34	5½	.57	1.47	.78
14	Balch Cave	154	22	6	1.79	1.76	2.04
15	"	127	21	6	.41	1.94	.42
16	"	207	23	6	.47	1.50	.62
Other Surveys from Cave Literature							
17	Ease Gill	8335	22	4	.78	.91	1.72
18	"	1492	17	3	1.62	6.08	.54
19	"	1270	18	4	.87	2.77	.62
20	"	748	16	4	3.34	3.29	2.02
21	"	820	32	3½	1.22	5.76	.42
22	St. Cuthberts	1308	16	4½	1.80	1.82	1.98
23	Ogof F.D.	515	18	6-4	.40	.88	.90
24	"	1265	17½	6-4	.24	.58	.82
25	"	909	19	4?	3.30	3.03	2.18
26	"	392	24½	6	.77	1.20	1.28
27	"	1903	27	6	.89	.54	3.30
28	Nidd Head	257	29	3½	2.88	10.88	.52

Another point brought out to a certain extent by these figures is at first sight a rather startling one. The accuracy is independent of the difficulty of the passage from the caving point of view. This at first sight is ridiculous - "obviously" the survey of the Primrose Path will be less accurate than the survey of the Beehive Passage. But if we are doing a Grade 5 survey we are reading our compass and clinometer to the nearest degree and our tape to the nearest inch - the difficulty does not come into it. Our measurements will be slower and probably more painful, but they will not be less accurate.

Also, we find surprisingly little difference between different surveyors. One of us is rather more accurate than all the others, but only by a small amount. Only in the case of a very careless surveyor would individual accuracy come into the picture, and so far in the Survey Group we have had no careless people wanting to become surveyors.

This brings us to the question of downgrading of surveys, a subject on which the writer feels quite strongly. Some surveyors produce a survey using the instrumentation of a certain grade, and then claim a grade lower on their published survey. This is just as misleading as claiming a grade higher, and no surveyor would be likely to do that. The writer has perpetrated this offence, Grade 5 being claimed instead of Grade 6 for much of Eastwater Swallet. So has Ford in St. Cuthberts and Stanton in Swildons. Probably in each case (certainly in my own) this was done in view of a statement in "Cave Survey" - "if the conditions are very adverse, a grade of survey should be claimed lower than normal". We have just seen that this "escape clause" is not valid, as the conditions have very little effect on the accuracy. Survey grades should be given according to the list given at the beginning of this article, otherwise the whole point of the C.R.G. grading scheme is lost.

Returning to our mass of figures with the assurance that our theory is a reasonable one, let us now take out certain values from the graphs as being fairly typical of Mendip conditions; say a 200 feet passage of 20 legs representing a rather "difficult" passage, and a 500 feet passage representing a somewhat larger one. The first would be typified by Browne's Passage in Stoke Lane I, and the second by the passage running Eastwards from the Beehive in Lamb Leer.

	3	4	5	6	7
200 ft.	11.5	3.53	1.24	0.74	0.38
500 ft.	6.7	2.50	0.85	0.59	0.30

These figures are the overall standard deviations of the measurements and we may make the predictions mentioned earlier. For example, in a Grade 5 survey of 500 feet of passage in 25 legs, the percentage error will exceed 1.70% only once in twenty times, exceed 2.55% only once in 400 times, etc.

But the most interesting thing about this table is not the actual figures, which are based on a large number of variables, but in the relation between the various grades, and even more striking, the results when an actual survey is plotted on to paper.

Let us take the first passage as an actual survey. It is a 200 ft. passage, so in the pages of the Journal one would plot it to a scale of 40 feet to one inch, giving a plan 5 inches long with a fair amount of detail. Taking an error figure of two standard deviations, and taking 0.80 as a multiplying factor to arrive at the plan error (our original figures are for the three-dimensional error), we have:-

	3	4	5	6	7
%	18.4	5.65	1.98	1.18	0.61
inches	0.90	0.28	0.10	0.06	0.03

A drawing of passages with the above errors incorporated is shown in Fig.8. For reasons of space this has been kept to a fairly simple passage with no branches; the detail is sketched in treating all grades as alike. Remember that the error figure of two standard deviations represents a figure that will be exceeded only once in twenty times; more than two-thirds of the time the error will be only half as great, so that we have here drawn a survey rather worse than we would normally get.

To enable comparisons to be made I have included the intersections of a grid without plotting the lines. From a normal inspection of this plan it will be seen that only Grade 3 shows any appreciable departure from the most accurate plan. Even this is sufficiently close to be quite acceptable for most normal work such as exploring the cave and predicting places to dig. Only if we take a pair of dividers and start measuring carefully do we find the discrepancies, and very few cavers do this.

The second of our passages is 500 feet long, and to get into a page of the Journal would be reproduced at a scale of 80 feet to an inch. The plans have not been drawn here, but it can be seen that similar considerations apply, and in an even more marked degree. This leads us to the rather startling conclusion that as far as the surveys in the Journal are concerned, then a Grade 4 is as good as a Grade 7, and even a Grade 3 is only slightly inferior.

If we consider the same plans drawn out as much larger surveys, as in the case of the full size sheets produced by the Survey Group, a similar situation is found. The plan of the 200 foot passage would probably be drawn to a scale of 20 feet to an inch, or even to 10 feet to an inch if we have collected a lot of detail. Taking the latter case as the most unfavourable one, we have a passage 20 inches long on the plan, with the following errors:-

	3	4	5	6	7
inches	3.6	1.1	0.40	0.24	0.12

In fact, our plans in Fig.8 are scaled up by 4:1. The error on a Grade 4 survey is now more noticeable, but for normal use it is perfectly acceptable. The conclusion here is that for large surveys a Grade 5 is as good as a Grade 7, and a Grade 4 only slightly inferior. A Grade 3 would not normally be produced to this size except in the case of isolated passages in a more accurate survey, and if the scale is anything like 10 feet to an inch even this is not likely.

Another major factor which should be remembered in considering the accuracy of a given grade is the fact that at the extremes there are other factors operating. In the lower grades of 3 and 4 we are not working to the limits of our equipment, and many of our measurements will be more accurate than required for the grade. At the other end of the scale the reverse applies. It is relatively easy for a Grade 6 or 7 survey to be lowered in accuracy by one or two doubtful legs. This means that the already small difference between the various grades will be reduced even more.

The main difference between surveys of the same cave to different grades is in the passage detail. We include here things like the exact outline of passages and the shapes of the chambers. This is the argument we have been leading up to in the preceding pages. While an accurate framework is the first thing to consider in a survey, we have seen that we do not need to go to extremes in our quest for line accuracy. Much of the time spent in making measurements to minute fractions of a degree or an inch would often be better spent in increasing the amount of detail and improving the offsets.

It might seem from the last paragraph that the writer is advocating less accurate surveys, but this is not the case. To fully record the detail of a single section of passage will take far longer than the time needed to read the instruments, and advantage should be taken of this to make the measurements as accurate as possible. But if one is not intending to record any detail, then there is no point in spending the time necessary to make accurate measurements. A simple line survey of Grade 6 or 7 has no more value than a Grade 4 survey.

The Cave Research Group recommend three separate types of plan. Class C, for exploration and organising further work, is based on Grades 1-3; Class B, intended for such work as "the correlation of surface and underground features, study of water levels...." is based on Grades 4 and 5, and Class A, for "research in geology, physics...." based on Grades 6 and 7. Class A demands "the highest possible standards of accuracy and detail".

Let us now consider the surveys that have been made on Mendip since serious exploration began at the turn of the century. Even in the very early days there were sketch surveys of caves such as Eastwater and Wookey Hole, which although diagrammatic, nevertheless fulfilled their purpose. These would now be considered as Class C surveys, as would be nearly all the plans produced before the war. In some cases, notably in the surveys made by Jack Duck, the degree of accuracy and detail was high enough to bring the plans into Class B, but these were the exceptions.

With the upsurge in caving since the war, and following the general recommendations of the C.R.G., virtually all the Mendip Caves have now been surveyed to produce a Class B plan, including a number of resurveys of caves such as Lamb Leer and Eastwater. It would seem that the possibilities of further work in this field are now very limited, but this is not the case. Mendip has very few caves and very many cavers. We should like to see many or all of the larger caves re-surveyed with the intention of producing a Class A plan!

This, of course, is not a thing to undertake lightly. A Class B survey of a major cave may take from half a dozen trips for a Lamb Leer to 25 or 30 for an Eastwater. For a Class A survey one could probably double this to arrive at a reasonable estimate. The thought of doing a Grade 6 Class A survey of St. Cuthberts would cause most individual surveyors to seek an excuse to go fishing at Weston, but surveyors nowadays come as teams rather than as individuals. A survey that would be utterly impossible for the lone hand with a motley collection of stooges becomes possible with a good survey team, and becomes practicable with a number of teams working together.

FIG. 8

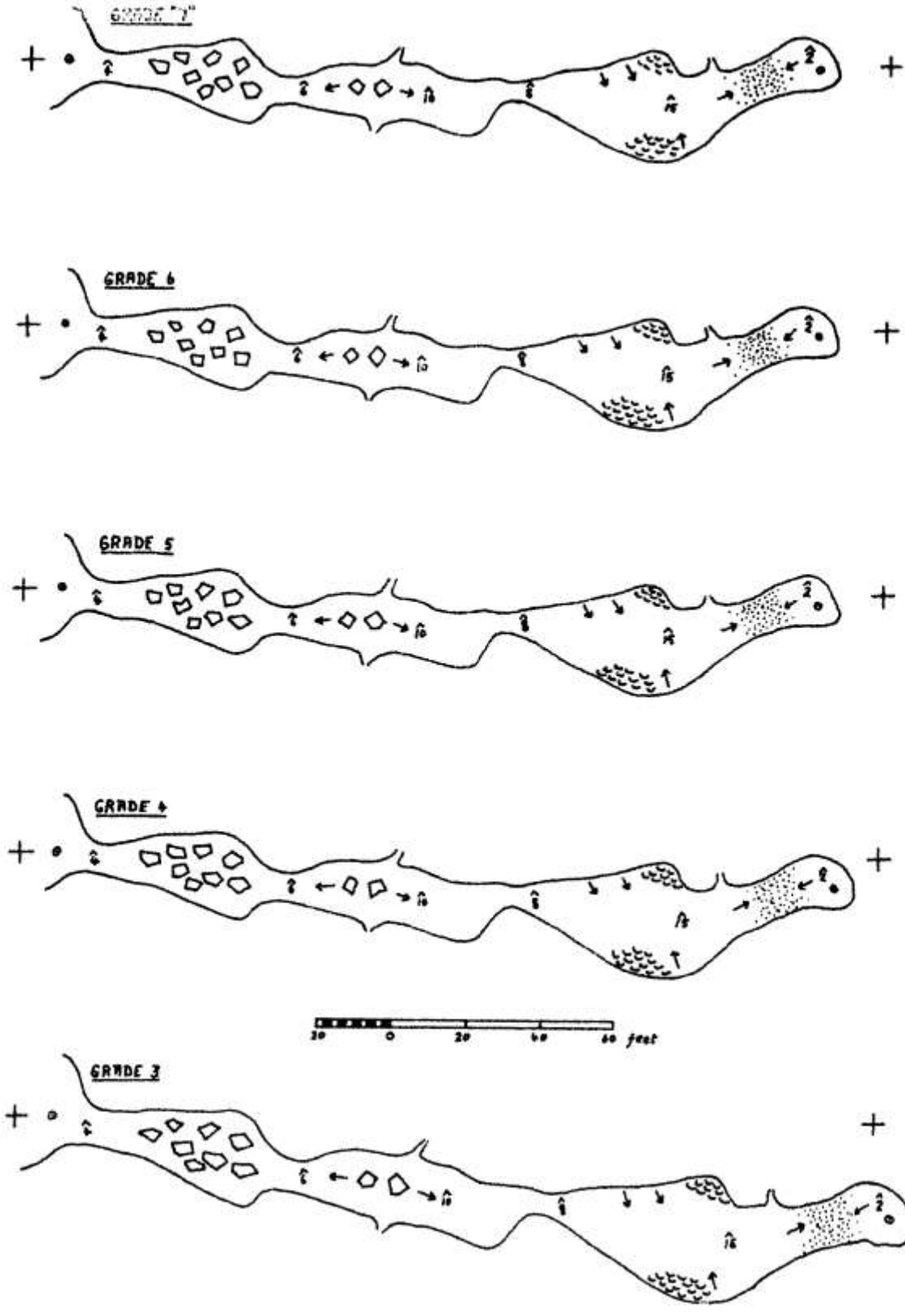
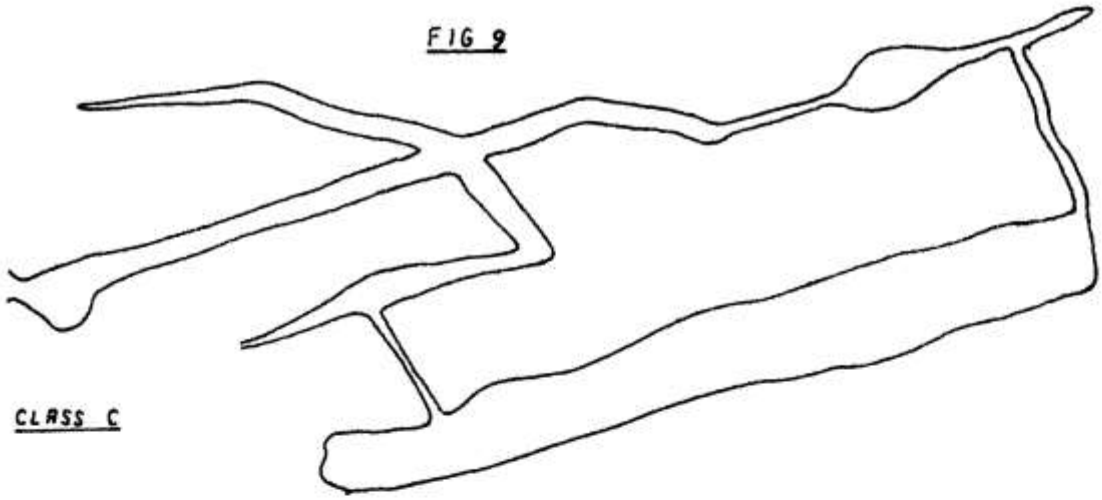
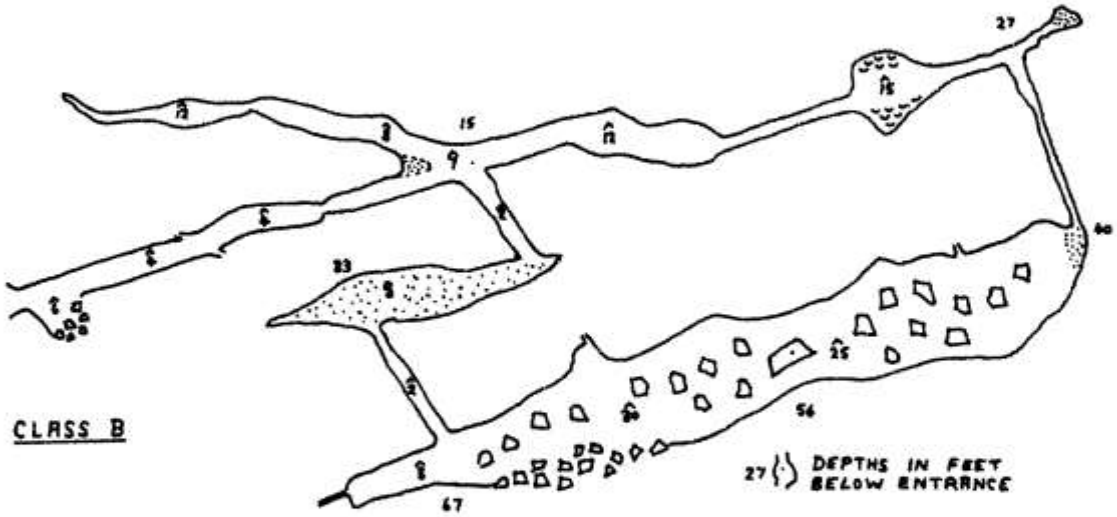


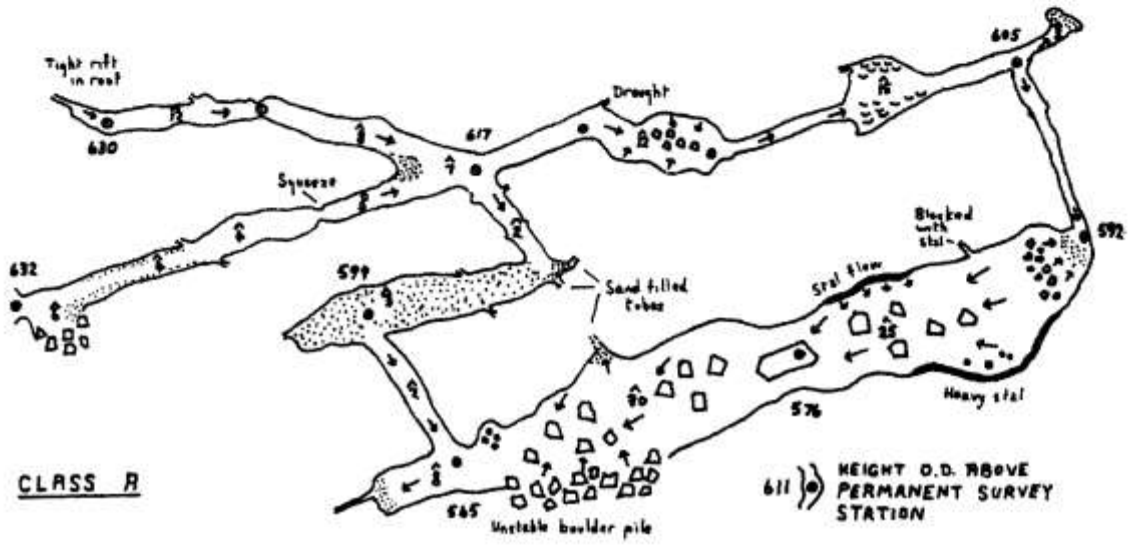
FIG 9



CLASS C



CLASS B



CLASS A

In Fig.9 I have tried to show the basic differences between Class C, B and A surveys. It must be remembered that a Class A survey would always be produced in large sheet form and not in the pages of the Journal. It is impossible to put all the detail one can gather on a full scale sheet with a scale of 10 feet to an inch, let alone on a duplicated quarto sheet. If the recommendations of the C.R.G. are strictly adhered to there should be a certain amount of detail drawn even on the Class C plan, but this is not often done.

An essential point here is the requirements of a Class A survey for detail. It is to be used for "research into geology, physics, etc." The geologists and physicists must tell us what details they want recorded and how accurately. Do they need water temperatures in degrees or tenths of a degree? Do they want the position of joints recorded to within 5 feet, or 1 foot or one inch? Do they want, as additional to the main survey, outline plans marked with easily located fixed survey stations for other workers to add details to their own requirements? Would it be useful to have multiple layer plans printed on tracing paper, in various colours?

This type of question and the answers must be fully discussed to obtain the maximum benefit from what will be a considerable task. We hope to have made the tentative first steps to this aim with the survey of Balch Cave (published October 1962) and we hope for suggestions, advice and constructive criticism from all who are interested in cave surveys. As we have stated earlier, Mendip has a very limited number of caves compared with its caving 'population', and if sufficient enthusiasm could be harnessed to such a project we could well pioneer a new field of cave science.

MENDIP NOTES

Cheramodytes

Longwood Accident

A pre-Easter gathering of Wessex cavers was rudely interrupted at Hillgrove on Sunday, March 17th, by a summons to Longwood Swallet, where members of the Bristol Technical College were in difficulties. In spite of the rain there were at least four parties in that cave, one from the R.M.A., Sandhurst, one from the M.C.G., and two of five each from the B.T.C. The latter had gone down at 1.45 p.m. after the rest, dressed as one might for a quick Goatchurch. This trip was neither quick nor dry. They went down as far as the Main Chamber but turned back early, as they had all got soaking wet. It was then the trouble started. One of the guests of the R.M.A.S. party, Jack Fell, sprained his ankle and took a very long time to get up the entrance shaft, which by now was taking water from the leaking dam outside.

The result was that the cave was blocked with cavers, nose to toes, all the way to the ten-foot overhangs. Here the last of the B.T.C. parties waited a long time, cold and shivering. When the turn of the last three came to climb the entrance shaft there was a lot of water coming down. They were John Veale, Heather Muirhead and Robin Gay, in that order. John climbed about 15 ft. up the ladder and shone his torch down to give light, but Heather (on her first caving trip) was quite unable to climb. After about 10 minutes John got weak as well, so gave them his torch, climbed out and gave the alarm. Mendip Rescue was alerted at 4.45 p.m. By 5.15 p.m. Heather Muirhead was dead, and when Robin was got out at about 6 p.m. he was as near death as anyone could be.

The fate which overcame this girl was exactly the same as that suffered by John Wallington in Swildons Hole in January, 1959. It is not generally realised how rapidly the condition of shock due to cold and exposure can lead to death. In Wallington's case it was an hour and a half; with Miss Muirhead it was less than an hour. She had had no difficulty in getting back through the S-bend, but after that she was in a continual stream of water.

These young people were not equipped either physically or by experience for a crisis of this sort, which was not of their own making. They had very bad luck. One does not criticize. One merely states that, when a caver is seen to be suffering from being excessively cold and wet, he should be taken to a dry part of the cave, where there is room for him to be walked up and down. M.R.O. should be alerted as soon as possible, because the other remedies may not be at hand. These are glucose to eat, warm dry clothing, and enough encouragement to revive the inward force.

Protective Clothing

Dressing in nothing much for a quick Goatchurch is very pleasant. It will not do for long or wet caving trips. People like Luke Devenish never feel the cold. He was one of the original Black-Holers in 1949. But Howard Kenney and Willie Stanton gave up exploration of those parts mainly because of the physical exhaustion experienced. After the advent of goon suits things changed. We went back to "Abandon Hope"; the sting was taken out of sumping; Double Trouble and Vicarage Passage gave way to us. Now that goon suits are virtually unobtainable cavers are adopting wet suits made of neoprene foam.

It looks as if these are going to be a "must" for anyone wishing to do original exploration on Mendip. But not every caver wants to do that. For those of us who cave just for the fun of it there can be no absolute rule, as to what constitutes proper clothing.

It is the same with boots. Rubbers or nails are equally good as soon as you get used to them. Steel toe-caps are valuable, because they make the boot last twice as long. They should be outside the leather. I had a pair with then inside, and as soon as the leather toes wore out the steel caps dropped out of the holes. The only thing wrong with creepers is that they offer little protection to the feet and wear out too soon. I am told there is beginning to be a serious shortage of theatre-caps at one of the London hospitals. These are admirable for keeping mud out of the hair.

Aggy-Aggy

I don't know what members of the Chelsea Spelaeological Society wear, but they certainly out-caved the Wessex party on the 24th March. Our party went with then to the Southern Stream Passage (this Journal, Vol. 7, p. 146). This subterranean hell is a dull, uninteresting passage with only half-a-dozen landmarks in a mile and a quarter. Like an aching tooth it goes on and on. The Main Stream Passage at the end is most impressive, but our party having got there turned straight back. After nine hours Howard Kenney was going distinctly slowly, Phil Davies was on his knees and Dave Causer was flat out. But the Chelsea party went on for another seven hours and discovered 3000 ft. of new passage. At the end of it Julia James emerged looking as fresh as a daffodil.

Swildon's Sump I

For the record, George Pointing went down on the 23rd March and renewed the hand-line in Sump I, since the old one had broken many times. He has now provided the sump with a nice thick cable.

The Bat Hole, Swildon's

On the 11th November, 1962, Bob Pyke, trying to interest someone in his horrible, tight, wet dig at the far end of Shatter Passage, took with him Oliver Lloyd. Oliver was far more interested in a little passage he found near the top of an aven close by, which terminates an uncharted tributary of Shatter Passage. The little passage has a typical phreatic shape and a thick mud floor. It goes south, and might with luck prove to be the only high-level passage crossing the Great Priddy Fault in Swildon's. This fault is a conspicuous feature of the end of Shatter Passage. It is also seen in Fault Chamber and at Sump IV.

On December 15th Oliver went down with Eric Hensler and Nick Hart and started digging. Nick made a most interesting discovery. On the mud to one side were scattered the bones of four bats. Some think they flew there, but that part of the cave has no draughts and was first entered on the 31st January 1961, while the skeletons are ancient. Others think they were carried there by the last of the post-glacial floods, which had been laying down the mud. Anyhow, they have given their name to the hole.

Further digging was done by Nick and by Phil Davies on the 9th March and by Oliver on the 23rd. After some 12 feet mud meets roof and is covered by a layer of stalagmite. But the mud is deep and the way on lies under the stalagmite. The skeletons were photographed and removed for identification. They are all four specimens of Myotis mystacinus, the Whiskered Bat. This species is still a common inhabitant of Mendip caves.

Bats in Ladder Dig, G.B. Cavern

Two years ago the skeletons of about a dozen bats were found in the grotto at the end of the new Ladder Dig Passage. Some of them were covered by a thin layer of stalagmite, others lay free. There is no known separate access to this grotto. I think it probable that these, too, may be immediately post-glacial. A rather indirect piece of evidence supports this theory. The species here represented are Myotis mystacinus (as in Swildon's), Plecotus auritus (the Long-eared Bat) and Myotis bechsteini. Now Bechstein's bat either doesn't occur nowadays in Somerset caves, or is rare, or doesn't get identified. The only reference to it is a skull found by the U.B.S.S. in Aveline's Hole in about 1920, a foot down in some pleistocene earth.

Lamb Leer

On March 17th the Wessex had a record turn out at Lamb Leer for the trip led by Roy Staynings. There were about 40 people there and it took quite a time getting them all up and down that pitch. Nobody tried to abseil it. Members of the Death Cult were elsewhere.

THE CHANCES AT CHEDDAR

D.C. Ford

The writer has just finished preparing an interpretation of the origin and development of the principal group of caves at Cheddar, namely Gough's, Gough's Old Cave, Long Hole, Great Oones' Hole, Sayes' Hole and Cooper's Hole. Such work always turns up ideas about likely plans to extend the known cave, and possible problems. The Mendip Caving Group has recently been permitted to carry out a very big dig in Cooper's Hole. The proprietor is therefore favourably inclined. The Wessex Club, with its large organisation and superabundant charm, may be able to win similar concessions. This article is written with the intent of inspiring such efforts.

The chances are rather good. These caves are the remains of an integrated system, the biggest effluent known in Mendip. The modern spring is also the biggest. Its mean discharge is about 18 million gallons per day. It has been calculated that it requires the run-off of a little over twenty square miles of the Hills to feed this flow. This is a very big area (so surprisingly large that the calculations were treble-checked!), larger than that of the surface drainage system directed into Cheddar Gorge, and implies a considerable extension of feeder caves to North, East and West. Passage dimensions in Gough's Cave and Great Oones' Hole imply a very much bigger stream than ever passed through Swildon's, our lengthiest cave to date. Some of these extensions could therefore be very good prospects.

It is convenient to begin by specifying what is not likely to be found. This is the (active, vadose) "Master Cave" of H.E. Balch and other writers. Balch[1] recounts a Twelfth Century traveller's tale of "Cheddar Hole", which is described as a large passage, up which a horse and cart might be driven. It possessed a river and tributary streams, and was so long that the end had never been reached. Balch felt that such a description could not be fitted to any known cave at Cheddar (taken literally it certainly cannot), and supposed that, eight centuries ago, a royal road was open to Mendip's principal master drain; the latter being air filled.

It appears probable that, in the past, the known system discharged at a series of successively lower levels, finally arriving at the present discharge in the closing phases of the last Ice Age. This is the very recent past in terms of Mendip cave development. The falls to lower levels were caused by surface streams lowering the floor of the Gorge at its outlet. But each time such a fall occurred in the past, the cave stream, instead of draining down and entrenching the passage it had previously occupied (i.e. cutting a vadose, accessible cave), dropped down to utilise a lower phreatic level that had been opened to a limited extent before, and discharged upwards from it. The level of the active master drain at Cheddar, then, has always been below the local water table. Sometimes flow was well integrated and a great passage bored, as in the tourist part of Gough’s, west of the steps to St. Paul’s etc. Sometimes flow was poorly integrated, being dispersed in many small bedding plane tubes and joint rifts. The present discharge appears, from the behaviour of the springs in flood, to be in the latter condition.

How far the active cave extends into the Hills before becoming vadose is not known, but it is probably a very considerable distance beyond the known caves. The active cave is therefore a diver's problem and most likely to be one that cannot be overcome because the system is too tortuous. If a horse and cart went up it eight centuries ago, the horse must have worn an oxygen set.

In parentheses, it is the writer's opinion that "Cheddar Hole" is that now known as Sayes' Hole. This has a very impressive, daunting, entrance, a stream at time of flood and extends beyond the daylight zone. These ingredients appear quite sufficient for the preparation of a good yarn!

The search for extensions at Cheddar should therefore be directed away from the active system, and to the abandoned levels of the past discharges. These are almost certain to be blocked by collapse or other choke at intervals, but might go a very long way.

The caves of the highest level. Great Oones' and Long Hole, can be written off. As Willie Stanton suggests[2], they appear to have drawn their formative water from the inner parts of Gough's Cave. So the latter place is where the extensions should be sought. Here, the prospects all lie beyond the tourist part of the cave, where digging could be conducted without any inconvenience to others.

The water always entered this headward area in the same manner, flowing down the dip from N.N.E. and opening a bedding plane type of passage with occasional excursions up joints. The openings occur at two levels; there are four important prospects.

At the upper level, the first of these inlets was the sole supplier for Great Oones' Hole and is thus likely to be of good size, if preserved. On Stanton's map[3], it is the first inlet East of St. Paul's, at c. 170' O.D. It is reached by turning N.E. under the Black Cat, and crawling over a stalagmite floor. The latter rises to seal the passage and bar the way.

Two other, historically later, inlets enter the upper level. The first is reached by scrambling due North from Mushroom Chamber. It, too, terminates in a stalagmite choke which is very close to the first inlet described. The two probably connect, and the first would be a better choice as it already extends somewhat further.

Immediately east of Mushroom Chamber is a smaller chamber. The north side of this leads, via two rifts, to a large boulder choke with some stalagmite. This is the last good prospect at the upper level and probably drew from the same source as the other two.

At the lower level, the prospect is the Boulder Chamber, reached by a climb down the 40 foot drop. The whole of the N.N.W. side of Boulder Chamber is a boulder choke. Before the boulders fell, the water that shaped the (very large) main tourist passage came through here, in the writer's opinion. H.E. Balch also suggested digging in the Boulder Chamber area, but

advocated the little westerly extension or the south side. These are down dip of the suggested choke. Balch clearly felt that in flood, water from the active conduit rose through his sites. The present writer thinks that the very rare floods in this part of the cave are fed through the northern boulder choke. If there is a connection with the active drain, the latter will be impassable, anyway. Balch's sites have taken water, feeding it north-westwards under the upper level and into the tourist cave. There are only short, heavily choked, links to be found there.

Unfortunately, all of the digs being advocated here are directed to the North where, in the south wall of the Gorge close by, there is a deep embayment. The undiscovered passages may run out into this embayment, the ways on thus being totally destroyed. But it is more likely that they, or some of them, will turn to the Southeast (technically, to the strike, which is the predominant trend of Gough's Cave), thus avoiding the surface. Seepage from run-off in the embayment may create collapse blockages. For this reason, the Boulder Chamber inlet, being deepest and thus furthest from surface interference, is perhaps the best bet.

One other place offers a good prospect. This is the terminal choke in Gough’s Old Cave. The Cave offers a technical problem which is best resolved by supposing that the water which formed it was an independent stream, distinct from the main discharge and drawing from different swallets. The cave is headed to the South, where surface interference should quickly dwindle away. The terminal choke is awkward, being cemented and vertically overhead. But it may be shallow - and much of the clearance could be left to the force of gravity!

1. H.E. Balch "Mendip : Cheddar, its Gorge and Caves" 1947.
2. W.I. Stanton Annual Report, Mendip Nature Research Committee 1951-52.
3. Stanton, op. cit.

LETTERS TO THE EDITOR

"Sir,

Windsor Hill Cave

When Mr. Oldham mentioned the beautiful grotto in this cave (W.C.C. Journal No. 88 p. 155), I could not help recalling a visit to the British Museum many years ago -when I remembered Mr. Balch had said in "Mendip - Its Swallet Caves and Rock Shelters" (2nd Edition) at page 120, that before the cave was quarried away "the long-sought opportunity has been taken by the British Museum to obtain the specimens necessary to reproduce in the museum the form of a limestone grotto, the best possible purpose in such a case as this."

I asked about this grotto but no one seemed to have heard of it. I was passed from one official to another, finally reaching an "August Personage" who resided in an office of immense size. He gravely told me to try the Geological Museum. I did but without success.

Has anyone seen the grotto (since it was removed from Mendip) and where is it now?

Yours faithfully,
T. Charles Bryant"

"Sir,

Llangattock Report

I was very interested to read the admirable article by Julia James in the February 1963 issue of the Journal. The accompanying diagrammatic plan was very well thought out and drawn up. There are one or two small inaccuracies which it might be as well to mention now and I set them out below:-

1. The extension of Phin Stream Passage downstream of 4-th Choke, first entered by B.S.A. members at Easter 1962, is approximately half a mile in length, not a quarter of a mile.

2. The statement that a Choke 5 exists between Choke 4 and the new extension of Main Stream Passage is only an assumption. There may well be one rather long choke. Only further exploration may reveal the facts. Dr. Lord may be able to shed further light on the natter with his survey.

3. The downstream sump may be perfect for diving but it shows every sign of being lengthy: a very slow dip down to meet the water and probably the same on the other side. It could form a lengthy blockage. It is about 12 to 15 feet wide, ideal for losing direction.

4. The two waterfalls in Main Stream extension are short (in one case only a couple of feet) but they do have deep pools in front of them which, although forbidding, are easily passed when water levels are normal. The waterfall in Southern Stream Passage is approximately two-thirds of the way downstream from Main Chamber to Main Stream Passage and is about 6 or 7 feet high. Again it is easily surmounted. The finely water carved roof of the chamber which it enters is very interesting.

5. Roof passages were found by B.S.A. and C.S.S. in Main Stream Passage extension and by B.N.S. and C.S.S. in Southern Stream Passage (see C.S.S. Newsletters). B.S.A. were the first into the longest of the passages so far discovered in Main Streamway extension - we have given it a provisional name of "Biza" Passage and it is just below the 4th Choke end of the passage.

6. Many people consider the First Choke as being stable but I suspect it is not as stable as it appears. There have been at least two boulder movements in 1962. It should be treated with the greatest respect, especially the left wall immediately below the 8' drop prior to entering Tudor Passage and in the crawl section of the choke proper.

7. It may not be clear that the sump referred to in paragraph four is the water inlet at the upstream end of Turkey Passage. C.S.S. members are no longer seriously contemplating a free dive here. They wish to live to continue exploration elsewhere!

8. The 200' of pretty passage (paragraph five) above North West Junction is almost certainly a "'rediscovery" of Straw Gallery first entered by B.N.S. some years ago. It is well worth a visit. I suggest it will connect with the South East limb of Helectite Chamber if pushed hard enough. Straw Gallery has some fine formations but the erratics are not the equal of those in Helectite Chamber. Where are the gypsum flowers??? There are some in Southern Stream Passage and one isolated but good specimen in Coal Cellar Passage.

9. Coal Cellar Passage and Midsummer Passage are known already to connect. A dye test using Rhodamine 'B' has proved that the water in both passages is the same. There is no doubt about the connection, the only problem is whether cavers will ever get from one to the other without going the long way round.

10. "Indent Passage, 600 feet" is presumably a reference to the extension of Trident Passage by Hereford Caving Club. It might be worth noting that a water tracing test linked the streams at Cliffs of Dover, Trident Passage and the first tributary on the left (going downstream) in Southern Stream Passage. This is omitted in diagram also.

11. Of the cliff face digs - also very promising, with draughts, are Ogof Pen Eryr and Ogof Daren Cilau. Both are in the quarry just before and on the Brynmawr side of the Old Daren Sunday School.

12. What is a "major cave"? Ogof Eglwys Faen is on the escarpment and runs to within an estimated 600 feet of North Wing in Agen Allwedd. It has a little over ⅝ths of a mile of passage (including an extension, St. Patrick's Passage, by C.S.S. last year) and presumably deserves a mention.

Yours faithfully,
Bill Maxwell"
(Wessex and C.S.S.)

"Sir,

Modern Climbing Technique for Cavers

I am sure that Charles Bryant intended this stimulating article on climbing techniques for cavers should stir up controversy, so may I be allowed to do some cheerful mud-slinging?

Abseiling, using a Karabiner and Sling, is certainly a caving technique that could be more widely used in this country than it is at present, although its applications are rather to North Country caves, with multiple pitches and large parties, than to Mendip. The classic method I've tried only once underground, and found that the increased friction resulting from wet clothing and gritty rope made things slow, difficult, and very painful, especially with holes in one's trousers! As to Charles' suggested trial of The Descendeur, he seems hell-bent to join the Cheramodytes Lamb Leer Death Cult (leather-jackets with skull and crossbones?). He might well be able to "do the ton" down main pitch, by use of this diabolical instrument. I have found it hard enough to operate one in broad daylight, let alone in the dark with water flying about.

Climbing-wise, the virtue of the Tarbuck knot is surely its ability to slip a little way, before tightening and jambing on itself, hence allowing a little more "give" as the falling climber is arrested. For this reason it is always used hooked into a karabiner on a waist-length. The idea of having what amounts to a slip-knot "opened-out and fitted around the waist" (which is Charles' suggestion for the caver without a waist length) appeals not at all to your correspondent, it sounds rather dangerous.

The idea of guarding the first-man-up by karabiners clipped to the ladder at tricky places sounds excellent. The possibility of ladder and belay breaking under the strain of a falling body, is obviously more than counterbalanced by the certainty of taking a flight to the floor if a fall occurs while not thus safeguarded. It would be interesting to hear from the tackle-warden how far a "standard" caver, well held from below, could fall on to a karabiner clipped to the ladder below him, without breaking the tackle. The strain would probably occur as a shearing-force on the wire, at the rung-wire junction. To an unmechanical mind this would seem to be a bad thing. A rough figure from the engineers in the club would give some indication of the maximum distance below the possible "peeling-off point", that a karabiner could be safely sited. Such a karabiner would be helpful if left on the ladder near the top of those pitches with a difficult take-off, where the rungs lie flush with the rock, e.g. the 20ft. in Swildons, or longer versions of it. In this sort of situation, though, why not simply dangle the karabiner over the edge of the pitch suspended on a separate belay, and not clip it to the ladder at all? All that then remains is to clip the rope into it without falling off!

Yours sincerely,
Robert Pyke"

15 YEARS AGO "Taperer"

Circular No. 9, December 1947, reports:-

"The Club started digging in the Hillgrove main swallet on August 4th. The first shaft was sunk at a point about 10 yards to the East of the site of J.H. Savory's original dig, and after quarrying to a depth of 18 ft., a sloping solid rock floor blocked further downward progress. Tunnelling horizontally a few feet to the West, a small open system was reached, the chief feature of which was an open rift which it was estimated reached almost to the surface. From this system a small fissure led back under the sloping floor of the shaft, and through this fissure could be seen a horizontal tunnel running North and South.

"To reach this tunnel it was decided to dig down through a mud-choked rift at the East side of the shaft, and after excavating about 8 ft, the horizontal tunnel was reached. This was negotiable to the South for about 12 ft. and a narrow slot sloped down steeply to the West into a further tunnel. This tunnel appeared to be directly below the floor of the West system, but before excavation could begin down through the floor a second shaft had to be dug to provide a direct lift for the spoil. After digging downwards for a further 8 ft., bringing the total depth from the surface at the second shaft to 38 ft., the second tunnel was entered but was found to be the upper portion of a choked rift.

"A windlass has now been set up above the second shaft and excavation is continuing."

Also:-

Withybrook Swallet

"P. Browne reports the discovery of a small cave, and has named it Withybrook Swallet."

THE YORKSHIRE EASTER MEET - 1963

Denis. Warburton

Over the last few years the weather for this annual Club event has been getting steadily worse, but by compensation the amount and quality of the caving has steadily increased. This year our usual guests, the Bristol University cavers were not with us, but in spite of this we managed to fill the hotel, overflow into the village and organise a large camp site. We stayed at our " 'second headquarters", the Crown Hotel at Horton in Ribblesdale, and the proprietor, Mr. Eastham, once more proved that he could cope with the irregular hours and excessive appetites of a large number of cavers. An incredible amount of tackle had been brought from Mendip, and at one time the hotel version of the tackle hut held 850 feet of ladder, some of it on loan from S.M.C.C. and B.E.C. There was also over a thousand feet of rope.

As early as breakfast on Good Friday there were a couple of dozen members present, and by lunchtime there were several parties underground, Phil Davies led a party into the Calf Holes-Browgill system, one of the few through trips possible, and then into Birkwith Cave, Both these caves are easy, a loosener for the more strenuous things planned for later in the holiday and a splendid introduction to Yorkshire caves for Alan Rigg, Jack Johnson and Bill Hanson.

Meanwhile, George Pointing was battling up the Sell Gill track in his Land Rover, carrying not merely the tackle and gear for a large party but also the complete photographic equipment of the filming team, Denis Warburton and Alan Surrall. This was a very useful service, as the gear included five large accumulators weighing about 1½ cwts.

Sell Gill was found to be an ideal cave for both a quick cave trip and a photographers' studio, and many members were impressed when the large chamber was lit by a one kilowatt searchlight, A number of photographs were taken and the tackle left in for the following day. A certain amount of tape recording was also done on the pitches, the language was remarkable for its restraint. Our Chairman, Luke, was meanwhile filming the surface happenings in the area.

The Saturday activities started very early when the author decided to keep up the traditional walk up Penyghent before breakfast, He found it cold and wet and not really worth the loss of sleep.

One of the main trips of the meet was scheduled for the Saturday, a double descent of Simpson's Pot and Swinsto Hole in a second attempt to make an exchange of parties. (It will be remembered that last year's attempt failed because of faulty information in one of the more widely circulated "guide books" of the North), But alas, the weather was against us, and although the trips were individually successful, the Swinsto party, Phil Davies, Bob Pyke, Brian Guttridge, Nick Hart, Tony Woolmer and Alan Wicks were held up by having to take extra precautions because of the volume of the water, arrived just too late to link up with the Simpson's team, George Pointing, Graham Stevens, Rodney Hobbis, Bert Elkins, Mike Sinmonds, Jim Giles, Mike Dale and Butch, who had withdrawn early as the amount of water

was considerably greater than last year, and the ascent of Slit Pot would have been too hazardous. However, the two parties both had good sporting trips and arrived back at the Hotel, late and wet but in good spirits. They would have been later still had it not been for the magnificent aid of the detackling parties, which included several members, of affiliated clubs.

Whilst the assault on Simpsons and Swinsto was going on, the remainder of the party helped Denis Warburton to continue filming, but with the deterioration of the weather the second pitch in Sell Gill, dry on the previous day, had become wet enough to make photography unpleasant, and after, a few rather damp film sequences the photographic gear was withdrawn and the tackle removed. The weight of the gear caused many sarcastic remarks, and as the party numbered only six the batteries were ceremoniously dumped in a shakehole and left, in spite of the cameraman's frantic entreaties.

By Sunday morning most members were ready to call a temporary halt to their more strenuous activities. This was fortunate, as Sunday was one of the wettest and most miserable days we have ever spent in Yorkshire. A party went up to.Gaping Ghyll to look at the caves from the outside, two walkers climbed Ingleborough, whilst others visited Hardrow Force and the Buttertubs. Everyone returned for dinner in a rather subdued mood which was only dispelled when the bar opened. A slide show was then organised, the hotel staff invited, and before long there was a full scale party in progress. Two birthdays, one a 21st, were celebrated. The rain came down incessantly, and as the level of the beer in the cellar decreased, the level of the river rose. The party broke up when some of the campers came in to say that the tents were awash! One or two of the campers then spent the night on the hotel floor.

Because of the weather plans for a sherpa trip into Penyghent Pot, preparatory to the assault to be led by Bob Pyke on Tuesday and Wednesday had to be called off and Monday saw many of the party starting off on their long homeward journeys. There were, however, still enough left to keep the flag flying. Graham Stevens led a. party of tigers on a "mystery tour" about which very little was revealed. Let it suffice to say that five experienced cavers emerged exhausted after a very fast trip and that one of the finest grottos of the north is still as beautiful as ever after more than ten years.

By Monday also, the cameraman had persuaded a few people to help with the removal of the batteries from the shakehole by Sell Gill. This party also did a little "surface work", inspecting the many sinks and shakeholes on the moors nearby. The Club enthusiast on digging matters, Alan Surrall, was seen to examine some of the better looking digs with an introspective gleam in his eye and he was strangely silent for some time thereafter. It is highly probable that digging tools will be included in the equipment for a future trip.

By this time the Easter Holiday was over, strictly speaking, but five members were left to run a rapid trip to the bottom of Marble Steps Pot on the Tuesday, thereby bringing the meet to its conclusion. The last to leave on Thursday morning report that it was still raining heavily when they left. We can safely say that this meet was the best we have had in Yorkshire in spite of the

inclement weather, and our thanks must go to the hotel staff and to all our members present for helping to bring this about.

BOOK REVIEWS

CAVING Pub. Autumn 1962 by East Devon Caving Group, duplicated foolscap.
Pub. quarterly, obtainable from: Phillip Tarbes, St. Dominic Savio College, Leatherhead, Surrey, at 1/6 per copy or 5/- per annum.
This magazine covers a wide area from Caving in Spain; Coopers Hole, Cheddar, with survey; Fissure Caves in Scotland; Aven du Marbore, Spain; The Pengelly Research Centre, South Devon; and a note of Michel Siffre, the French Speleologist who spent over 2 months alone in a French Cave.

THE SPELEOLOGICAL GROUP REPORT NO.1 JANUARY 1963 Duplicated quarto, published monthly, obtainable from: J. Fortnum, Comer House, Maidenhead Road, Cookham, Berks, at 10/- per year.
Yet another Caving publication to choke up the resources of the Speleo. Librarian. This one records details of reorganisation of the Yorkshire Cave Rescue Organisation; the underground laboratory at Moulis in France; Correlated Orientation of Ear Movements of Horseshoe Bats; the 1962 Derbyshire Caving Congress; and some notes on "Caves not in Limestone", being part of the Chairman's address at the A.G.M. of the Derbyshire Caving Association.

THE BRITISH CAVER VOL.37 SPRING 1963 Edited, Produced & Published by G. Platten at Rotherfield, Fernhill Lane, New Milton, Hants. 8/6d. post free.
One hundred and four pages crammed with information from Afton Red Rift Cave, Devon; Fontana Christiana, Switzerland; The Gouffre Berger, France; Lamb Leer; Blackmoor Swallet in Velvet Bottom; Maltese Caves; West Staffs Caves; Padirac, France; Cuban Caves; to many new Welsh Caves with unpronounceable names. Of particular interest to Cave Archeologists is the article on Prehistory of the Basque Country (France & Spain) by E. Nolte y Arambura. Contains something for everyone.

BATS by GLOVER MORRILL ALLEN, Late Professor of Zoology, Harvard University.
368 pp. 58 photographs & illustrations. Pub. 1962 $2. or 16/- from Dover Publications, London (through any good bookseller).
This unabridged republication of the rare 1939 edition is really a standard work on Bats. It contains a valuable 256 item Bibliography, giving all the major references up to 1939.
This book begins by describing Bats in Folklore since the very earliest human records. It has been invested with a glamour of the supernatural from the days of the Ancient Egyptians, whose tombs and temples it inhabited, right down to the present.
This volume, prepared by one of the world's foremost experts on Bats as a life form, is written upon a middle level that can easily be understood by a layman yet is still of interest to the professional zoologist. It embodies a lifetime of research and study, including many expeditions to primitive parts of the world to gather and observe local bats. As a result of this work bats should have more friends and fewer enemies.

Der Fledermausfänger