Nature and Method of Invention

Not obvious to those skilled in the art.

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Introduction.

The subject is invention, essentially to order, as distinguished from development, or design.

Development is the process of evolving a design or process by incremental steps, usually experimentally derived. In a competitive situation he with the largest army working on the problem usually wins.

Design is use of known engineering methods to produce a concept or product. It does not require significant hypothesis beyond the methods known in the art. It is frequently coupled with development.

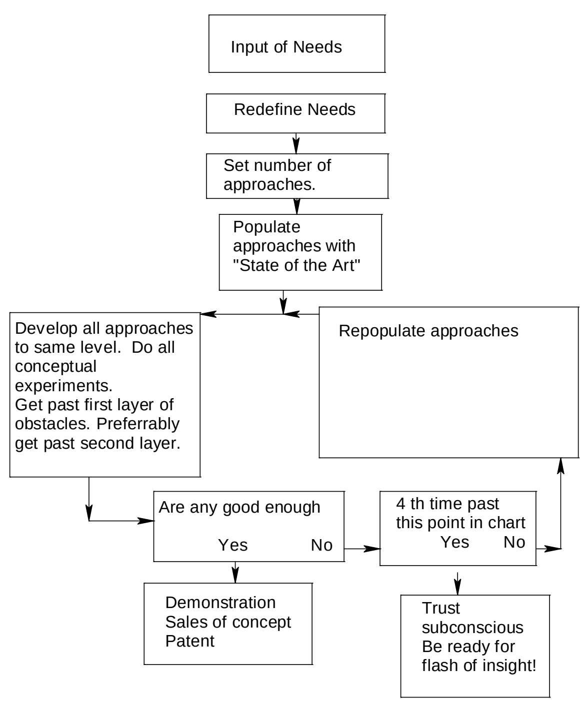
A true invention contains a leap of understanding that is not obvious to those skilled in the art. Generally an epiphany is involved in which a new understanding or view point of the problem is revealed. This is extremely pleasurable, and somewhat addictive. It also can change the world.

We will be discussing a systematic way to set the stage and quite often generate this new understanding. In the process, quite often highly improved solutions to the problem are generated in the process of preparation for invention, which although useful and sufficiently novel for patent work, really lack the full novelty of true invention.

Although the methodology includes education, skills, methods of thought, individual methods, team methods, and support systems, there is a simple fundamental method, which avoids most of the common errors seen in large industrial laboratories.

This method (obviously not the only one) has resulted in a series of 53 U.S. Patents (listed in appendix). It is most effective for a people with a broad rather than specialized technical education. Portions of the method are applicable for simpler or specialized problems.

The Method Flow Chart



The method flow chart starts with the input of a need, or unsolved problem. A larger version is in appendix 2.

The needs are usually external, in a very undefined form, and need to be carefully redefined to be both explicit and of maximum scope. This defines success, as well as enabling it.

The number of approaches needed has to be defined. There is a very strong tendency to favor the latest bright idea, which very often is not the best. Working on a number of concepts in competition at least during conceptual work assures choice of the better one, and provides material for a defensible cluster of patents later. My default value is six approaches.

The initial set of alternatives is populated by state of the art knowledge, optimized for this problem.

These approaches should be as different in concept as possible. This is the first place in the process where a broad rather than specialized training is an asset. Procedures which eliminate the problem should be included if possible. A minimum of hypothetical approaches are used at this stage.

In the iterative loop, the next step is to advance all concepts past the current problems to nearly the same state of development. Some experiments of a conceptual type are often needed at this stage to confirm ideas. A conceptual experiment is designed to verify and idea, and thus indicates yes or no. It does not usually require great precision. I tend to make them appear more crude than they are to tease the incremental approach specialists. Coffee cans with labels showing where appropriate do this well. Do make sure the experiments are well enough planned to get very high confidence in the answer. This is the portion of the iteration loop where most of the time, experimentation, engineering design, and testing are done.

The second step in the iterative loop is to evaluate how well each of the answers solve the problem. Quite often there is an adequate solution at this step, and possibly several. If there is an adequate answer or more then drop out of the loop and refine the answer, prepare demonstrations, and sales presentations. Make sure you present the material in a form, and with types of thinking that others can understand.

If this is the fourth pass around the iteration loop, and all work has been done diligently, put it aside in an orderly fashion, and relax. You have stored a great deal of information about the problem, and developed motivation. In about a month, if possible your subconscious will present a solution, usually in a very interesting unique form about the problem. Keep documentation materials available particularly at night and record the idea when it surfaces. Left undocumented, the idea fades and is garbled in memory later, Documented with initial calculations, it will persist in memory, and usually these calculations can be lost . without damage to the memory of the concept. This is the stage that usually involves the epiphany. Proceed directly to development and testing of the new concept.

If none of the current concepts are good enough and it is less than pass four, proceed to develop a new population of improved alternative solutions. A fairly large number of methods used will be described later. This is the section of the iteration loop that uses most of the skill and diversity available. Most of the "classical" specialized methods of invention have the initial conceptual work done at this part of the loop.

Continue around the iteration loop.

The research environment, including resources, team/competitive effort, and active suppression of invention are important. These are mostly known and traditional quantities which will be discussed after the method discussion. Patent documentation requirements must be satisfied, and are discussed in the appropriate appendix.

End of Introduction. Beginning of detailed Description.

Needs Input

This is quite often not done by the inventor, but is brought to him when he has some reputation and the problem has proved intractable for others.

One of the types of "needs" that the inventor may generate happens when the unexpected happens. At the moment something happens and is well observed that is contrary to current theory (serendipity) the observer knows something "unobvious to those skilled in the art", and if it can be made useful , it is quite often patentable. The needs then is to find uses for the knowledge, and most of the standard method can be used.

An already running iteration on a project often generates a well described need for a function to complete the invention. This can initiate a whole secondary invention iteration loop. In this case the use of multiple approaches increases the probability that one of the approaches will really work.

Instrumentation, experimental, and fabrication needs for Edison type or empirical research often result in the inventor generating a needs description.

Redefine Needs

The next step is to redefine the need by careful study of the need and the context of it. This should be generalized to include all approaches which will eliminate the problem. Careful analysis can drastically reduce the leap of intuition required and provide a much firmer basis for it.

Early elimination of easily solved problems at this stage allow concentration on more rewarding ones and avoids having your invention by passed later. Failure to eliminate these quick answers really results in wasted effort and an extreme feeling of "how could I have been so stupid" when someone else does it right.

Alterations in procedure or software (making sure you do not step in the hole in the floor, not fixing it) instead of inventions are preferred at this stage. This usually requires close observation of the problem and working with the people who are most fundamentally (hands on) doing the work. Often the managers have a very distorted view of things. The people on the job sometimes only need the "clout" of the "distinguished inventor" to get their idea listened to. Always give credit where due, and blame the system not people for communication problems. (90% of organization problems are system anyway.)

With optimum procedure, the residual needs are better defined.

Next is to define the physical science portion of the problem. Most problems change drastically with choice of the discipline used. The change is even more apparent when a mixture of sciences are used. In cases where occasional out of tolerance process is encountered there are two approaches that are best done simultaneously (patent separately), increase precision of the process, and increase the tolerance of the result. (If possible kill the problem twice dead.)

Inventors like writers occasionally run into a block, and it is quite often at this stage in the process. One method of overcoming this is to just build something that will do the job, but it is quite often unbelievably ugly. The old Navy term for such a thing was a kludge.

In the process of putting this little monstrosity together, the needs description for the invention will be clarified enormously. The major hazard is the administrative types quite often confuse the thing with a real answer, and once in awhile, it really is a useful answer.

Possible Short Story on color Verifax.
Partial measures from the various sciences may shrink the remaining problem significantly.

Redefine Needs Version 2

First study the way the problem happens on site if possible. Learn how to make the problem happen, and talk with those who really are facing the problem.

Become fully familiar with those who have worked on this before, the approaches and particularly the quality of work, and the constraints put upon them. Evaluating the quality of work by the people asking your assistance, and which approaches were "forbidden" is critical, particularly if you are coming in as consultant to save an existing project. If you can do this between the time the first meeting is scheduled and it is convened, you may have time to make one pass around the iteration loop. My experience has been that in industrial research a group was originally gathered to address the problem, and a totally paper study unsupported by any physical experiments was used to select a single highly probable answer dominated by a single physical science. When I was involved these choices were almost always the first choice I would have found, but unless I just fell into a very good answer I would never start with a single approach. This allows designation of one and only one specialist as project manager. This manager has large degree of his status on the line. As long as the science is confined to his specialty it usually is meticulously done. You are called in when reality confounds the original estimate and there is NO back up.   Knowing this allows you to redefine the needs by exclusion of a major alternative, and I strongly suggest you let them know how much work they did well for you.

Alternatively you may get requests where only a low prestige person has really worked on the problem or identified it. Learn everything you can from them. Make the problem happen with your own hands under their guidance, or at least use everything you have to watch them do it. Sometimes a nearly invisible happening like a small spark, can show you a whole new field of patentable inventions after you fix the problem. Remember to give them credit, they may feed you more ideas later. Respect for skilled hands and implicit knowledge (that which can not be verbalized) should be learned early. I have too many stories about that.

If it is your own problem take the time to really define the problem.

Do any experiments reasonable to define just what you need, and if possible tolerances on the results. With extremely rare exception a perfect solution is not possible but most of the time good enough can be done.

Each major science used to answer the bulk of the problem generally has different types of specifications, and these are violently changed by constraints imposed by other disciplines. A typical power struggle ploy in research is to know this but not admit to knowing it to use specialties outside of the assigned project to force impossible specifications on the project manager. Requesting impossible tolerances for manufacture is also commonly used. (I once had copier manufacturing people claim that if they were working with a design originated in the research laboratory, they could not make two successive rectangles of aluminum within 0.125 inch of the same width.) Identify tolerance accommodation already in the system. Image scanning story.

Stability of any mechanism used is important. If it will only work for a short time it is NOT usually a viable answer. Similarly real manufacturing tolerances are critical, because they impact the price. It was important to know in the 1970s that plastic molding could be done to tolerances of 0.0001 inch or 2.5 microns. Part of the needs is must be that the solution is able to be reliably and relative to the effect inexpensively manufactured.

All of the organizational nonsense must be separated from the good information before you can really start good work.

Quite often when a device is desired, the problem should be broken down into several different sections each of which is treated nearly independently. For example a device to very slowly move the plunger of a syringe to provide painless injections, must have a means to hold the syringe, depth of injection control, sterile handling of the syringe tip, a method of working with various plunger start positions, a rapid easy reset, protection of the drive against breakage when the syringe bottoms, a driving mechanism, and speed control. Because all of these functions are needed each must be assured with higher probability than a single component problem.

The first stage is to generate a really bare bones statement of what must be done. The option of avoiding the problem must be included, as well fixing it after, and any combination of them. This should be in terms that do NOT favor any one type of approach. If that can not be done a set of equally ranked descriptions for the different sciences must be generated. Absolute truth and honesty is invaluable.

Example:
Film was getting fogged by electrical discharges inside coating machines. Instrumentation shows that the plastic film base is getting charged on the surface from contact with rollers and carrying the charge into the machines where it accumulates, until it arcs at full design coating speed. The short term answer of running the machines slow enough to avoid the problem is costing production money. This is happening at low

enough charge levels so it is not causing failures of coating the film by moving the curtain of emulsion by electrostatic forces.

General answer:

- Stop the arcs.
  - Official answer by chemists in prestigious electrostatics department.
    - Change roller composition so it does not charge film.
    - Do not notice that it is a single fragile molecular layer on the roller that controls charging. The slightest contamination or wear will change it.
  - Alternative #1. Machines are acting like Van DeGraff accumulators so ground them
    - well. This works if the discharge is between machine parts.
    - Problem, a loose ground and it might start again.
  - Alternative #2. Use Grid Controlled Charge Neutralizers promoted by Carl Gibbons
    - to erase the charge on the film. (I invented the things for my use only. LFF)
  - Note none of the alternatives are mutually exclusive, and the later two are robust answers.

However Carl got pushed out of Kodak for increasing color coating machines speed 5 times using only the charge neutralizers. A year later the embarrassed electrostatics department that pushed him out was disbanded. These same devices were a key part of Kodak xerographic copiers.

So far we have discussed what to do, but how to do it is more important.

1. Trim off all excess modifications of the need. Keep It Simple.
2. Multiple disciplines will be used for solutions so Keep It General.
3. Review and test mentally that anything which satisfies the resulting need is adequate.
4. Check if a straight "by the book" answer, or one in an unexpected technology gets it done or reduces the scope of the required invention. NEVER reinvent the wheel if it is not needed.

This whittling the need down to the essential core takes understanding, and hard work, but is essential. Avoiding invention by assigning the problem to the correct experts, allows you to concentrate on things where you are developing a competitive advantage, which is good for all concerned.

Set up the number of alternative approaches.

Having multiple approaches is valuable to avoid failure because something unanticipated in one approach fails to be solvable, and to generate enough valid alternatives so you can choose the best one. It also allows going back to the procedure to get multiple answers for a defensible patent position.

Unless you already have a very good solution, and the use is mostly internal, one is too small a number. The more important the problem and more technically challenging it is the more approaches you will need. Some if not most which initially appear very creditable will turn out to not work at all. By now from the redefinition of the needs you have a good idea of just how risky this problem is. Too many alternatives slow down the iterative process of generating an invention. 6 is a good number for either a moderately easy important problem, or a difficult less important problem.

I have had five alternatives mule out (fail) on me in a process where theory was inadequate.

Develop the first N alternatives.

Almost always start with procedural/software methods. These are quick to implement, inexpensive, and because there is no physical equipment to fail, limited only by operator reliability.

A short story:
In amateur furniture construction, I have had a problem with the wood glue preventing the stain from penetrating the wood, resulting in white splotches adjacent to the joints. The traditional method is to glue sparsely and very carefully (costing some strength) and stain after assembly. If instead the parts are stained

prior to gluing, the glue which is clear does not leave any visible marks, and because the stain fully penetrates the wood without changing adhesion, full strength is achieved. It does require planning for a different order of operations. This avoids having to learn or devise precise gluing methods. Generalization of the problem so that having the glue on top of the stain was an option solved the problem. This is also an example of a solution which leaves you with the "How could I have been so stupid?" feeling.

Any method which avoids ever generating the problem of the redefined need is as good as one which fixes the problem.

Next the problem should be attacked with the physical sciences applicable. Start with a primary science for each proposal, use the others available, then if this turns out to be a candidate for invention, extend an appropriate hypothesis beyond the current knowledge relatively conservatively. If no extension is required you have an engineering solution in hand and can proceed to demonstration.

The art of reasonable hypothesis is worthy of some discussion. The hypothetical phenomena must agree totally with known physical laws. These are best expressed by the fundamental equations and statements.

In many sciences assumptions are made about the relative size of various material constants or forces involved so that simplified approximations can be used. Solid state physics makes gross assumptions about semiconductors, (experiments much longer than the dielectric relaxation time, and essentially a sea of free carriers inside the material), which are both false in xerographic applications. Using the full and usually original forms of the laws of nature (First Principles") gives you access to areas of science the specialists can not go into safely. In addition, it is a much more robust way of learning general science than rote memorization. I have had a very good PhD mechanical engineer try to force a problem into a textbook answer when it really was quite different. What rote memorization is good for is taking tests in school.

Do a repeat derivation of almost everything you can, and treat all text book equations that are not "proofed" by active use as suspect to typographical errors, particularly when there have been a large number of editions of the book. In consulting experts make sure all approximations are checked to make sure you are satisfying the conditions required.

Once you have established a probable but unobserved phenomena, rough out a test for it, and move on to populate the next alternative starting with a different core science. Each starting point ends up with a different proposal. The more different the mind set is in each science used the less likely the resulting proposals will share the same difficulties. Thus you want the greatest possible diversity of talent, at this stage, not a narrowly defined set of similar experts. Invention is only for those problems where a predicable engineering path fails, so you want in any team disproportionate representation of minorities. If you have to do this alone, learning the ways of different people thinking about things allows you to construct an imaginary and vociferously arguing team in your head. I tended to walk a connecting corridor with no offices for this, and completely frightened my technician with what were reported as intense scowls. She would peek around the corner and retreat. It works, but also gives you quite a reputation.

Develop All Approaches Iteration step 1

At this stage we have multiple approaches which each have an apparent reason why they will not work. Some of them may have two layers of such reasons. Remember these apparent obstacles are what will make the result "unobvious to those skilled in the art" and probably patentable. Also at the moment you eliminate an obstacle you are the world's expert in that small field.

From the previous work you should have one or more hypothesis about a test that should provide an answer to this problem. These MUST be key to the method, and an experiment that will verify or deny this approach needs to be implemented. The experiment should be simple, convincing and have a virtually undeniable conclusion. This is not the sort of stuff where we are working for an additional decimal point in determining a physical constant. A very clear yes or no result is essential. Do the experiments cleanly starting with the highest probability alternative. Only if it turns out to be a really exceptional answer go to demonstration, and sales of this idea, while preserving your options to return to the other answers. (Multiple conceptually different solution are a good defensive patent position. Someone else will often patent and claim as an improvement your discarded inferior but workable solutions.)

Solve or demonstrate the key problem first experimentally. Do the experiment at a scale of equipment that approximates the end use. I have seen a digital recording deck made six foot square instead of six centimeter square to provide a quiet last year before retirement.

At the other end of the size spectra, I made a set of test beds for xerographic copier designs, while I was forbidden to make anything that looked commercial, that just “happened” to condense into an office copier that would fit in a desk drawer space of a desk.

The exception to this is if an operating range, cycle or material must be determined. This leads to the purely empirical (Edison) type approach, which is extremely labor intensive. Even working very hard to avoid this sort of thing, you will find a large fraction of your professional life doing this slow and expensive work.

The goal here is maximum productivity and signal to noise, so that small differences can be reliably identified and optimized. One initial spread of experiments using available tools and good statistical designs is strongly suggested. This is used to make a ball park estimate of the amount of work required and locate the step or steps in the experimental cycle that will limit the rate of work. Often a traditional but intolerable practice in the establishment will be using up 90% of the cycle time. Tolerate these delays only if a short series is indicated. If the cost of fixing the delay is less than tolerating it, attack this delay directly, developing appropriate tools if not available, but buying them if feasible.

If the form of a relationship is pretty much known, testing for the values of the constants in the equation empirically is much easier than blind trial and error. I have a quick basic program, Itfit.bas, which is designed to fit a number of commonly encountered equations to data. This sort of tool can vastly simplify data reduction by providing an easy fit to transcendental equations. The iterative fit should not be used where an explicit method of calculation of the fit is available. See Appendix Q45.

Acceleration of the experimental process is so important that two examples will be given.

Prototype and specialized equipment requires time to build. The machine shop practice was to minimize the cost of the machinist time by having a waiting list for them of at least one month, unless you had an extreme priority (usually repair). This was prior to cutting metal. I had worked in a robotics laboratory, and knew the operator of the first laser mill Kodak acquired, as well as the instruction language for the mill. As a result I was able to make a program (certainly not optimized) that generated cutting instructions from my engineering drafting files. I also made a program to generate gears. Stocking standardized blanks of methyl methacrylate in the laser room, and keeping a standing labor order with the technician, James Buckwell, let me Email him the instructions and have parts kits within 24 hours. It did require that I design for parts cut from flat sheets, but having turn around on designs 30 times faster than other research groups at significantly lower cost was worth it for 20 years. If the need was extreme and before lunch, I did get some parts delivered during lunch less than an hour after being Emailed. From personal experience, use of left over strange colored plastic in instruments will work, but can make you rather notorious. They tend claim you chose those offensive colors. Black, white, and clear seem to be socially acceptable. Lavender and yellow are NOT. Black is needed for optical assemblies.

The goal was to identify a method to drastically reduce the amount of water needed to wash X-ray films. Each washing experiment required that a film sample be analyzed for residual hypo. The process of analysis at the time was extremely labor intensive and required two hours for a specialized talented technician to measure four samples. The waiting time was two weeks. We expected to have to do hundreds of such measurements.. There was a very fast, but imprecise method also available. By taking advantage of computerized instrumentation, I was able to make the fast method more precise than the standard approach, useful by unskilled help, and provide results within 30 seconds after insertion of a sample. The computer also produced digital records of the data to avoid transcription errors, and facilitate data reduction. This allowed our research group a productivity in this field previously unknown and made this an easily managed project. The instrument was laser fabricated, and used in other projects. At the time I lost track of it, the standards group was considering it as the new standard method of analysis.

Plan your experimental series very carefully. If you have a verified theoretical background for it, you can exclude large sections of work, or optimize the spacing of the experiment. For instance chemical reaction rates usually go as integral powers of the concentrations of the components. In a system with two competing reactions, where one is desired to go faster than the other, and both fast, identifying the power dependencies allowed generation of a developer which developed the exposed color film without any color being made with the first reaction, then developed the unexposed color film forming a color image. This was called "Reversal Transfer Process #8", and was one of the instant color processes for camera use lost to the public when Kodak and Polaroid ceased working together. Determining the power dependencies was done by varying the concentrations by ratios, instead of small steps, and using log - log plotting paper to determine the power dependencies in that era before computers.

Only when you are really without a clue over a range of options use purely Edison or try everything approaches. Even here, modern statistical partial factorial experimental design can help. Before starting this approach make sure there is a good probability of getting results. Really check your assumptions, because an commonly made incorrect, but identified, corrected assumption is usually something that is not known by those skilled in the art.

Evaluate Approaches

First make sure they have been equally developed, by reviewing the status of all of them. This also tends to equalize your enthusiasm, so you can be a nearly unbiased judge. If any of them are not equally developed you are not ready to do the evaluation, so go back and do the hard work.

Second recognize the attrition. Some of the alternatives are much worse than the others, and probably do not have any conditions under which they will perform better than the others. These can be dropped, either now or in the next step.

Quite often the needs description has multiple parts, and conditions under which the solution will operate. Some solutions only will work over part of the required range of requirements. Tabulating all the alternatives region of operation should be now done formally. This should be done in way that shows up on a single sheet of paper. If it takes more space than that your needs description is excessively complex. Quite often in the process of doing this some surprising conclusions become obvious about which alternatives come closest or actually manage to fulfill all requirements. For a defensive patent position or competitive analysis, the somewhat less than optimum solutions are needed. If a currently unknown patent surfaces these may be all you will be left with at this stage. This documentation is important, and should really be preserved. If you are working in a team this is a very important stage of the process.

With the summary in hand, you should be able to see if any of the alternatives on the current iteration are good enough. You should have a good idea about the probability of doing much better.

If you have a winner, preserve all current alternative options, and drop out of the iteration loop and go into the finishing up stage.

If Fourth iteration Go for Subconscious Approach

By the time you have evaluated three cycles of alternatives diligently, you have fully studied the problem, and the reasonable alternatives. Your mind is fully loaded with all the essential information, but you have been working hard enough you are establishing a repetitive pattern of thought.

If you got into this sort of work because you LIKE it, your subconscious mind is also working on the problem. In my case it seems like I have a very bright, egotistical 12 year old silently working on the same thing because it is fun to show the adult version just how much smarter he is. So relax and let the kid play. I do mean really relax, except once in a while you should get a urge to check some detail that you can not explain.

In my case, and quite a few others I have talked to about this there is a minor problem. This "kid" will tell you his results just one time. It tends to happen when you are most relaxed, like at the edge of sleep in the middle of the night. The transfer to conscious awareness can be very short lived if you do not pay attention, and becomes scrambled beyond retrieval. I lock the information in by immediately writing it down, and doing the first crude approximate support mathematics. The process of putting it on paper locks in access to the ideas, and appears to force a short dialogue with the other portion of myself. These papers are not needed, but convenient later.

This usually is such a well worked out solution, that only minor refinement and experimentation is needed. Very seldom is the result a false lead.

If you are running a team approach, this type of solution must be provided for, in such a way that there is no embarrassment for whom the lightening strikes. Immediately scramble the whole team and check this thing out, if it passes even a moderate bit of testing. Failed inspirations of this sort can lead to developing new talents for invention. The intellectual excitement of the new concept can inspire others to amplify it beyond almost any recognition. The combination of child like imagination, and discipline in attention to details takes effort to develop.

Finally this sort of answer is almost always easily patentable.

Building New Approaches

This is the portion of the process where most of the intellectual effort will be expended. Basically this is engineering beyond the end of the textbooks, and/or between supposedly unrelated sciences. It is exciting and highly entertaining.

There are a lot of methods involved, and several types of reasoning to be discussed. The discussion will start with the relatively conventional approaches and work into stranger ones.

Outline for Increasing Probable Solutions.

I. Completely detail lack of coverage of operating parameter (space) of current versions.
II. Recheck problem definition to make sure limited solution can not be used.
III. Check for combinations of previous answers which together would cover whole space.
IV. Check for adding one degree of freedom to each of existing designs.
V. Add select members of unevaluated solution candidates
VI. Look at different sciences for approaches.
VII. Blue sky method (because it is addictive last alternative)
    A. Hypothesize useful phenomena fully consistent with nature not in your literature.
    B. Team type reasoning approach, if single person use mental model of team discussion with drastically differing approaches from each aspect. This is where you need disproportionate representation of minorities. Note try not to argue with yourself out loud where others can hear. It frightens the civilians. Real teams can work well both cooperating and trying to top each other in overcoming obstacles.
    C. Childhood, or pretend way of doing the problem. Imagine a black box, doing the job, then detail it a step at a time looking into it. Repeat from different mental and physical approaches. A support for an object at a given altitude and position above a floor requires a means for transferring the force of gravity on the object to the floor from that height. Reasoning can start from the object or floor or both, and can include helicopters, ceilings, air

jets, optical pressure levitation, and of course tables. It is also possible to rotate the required functions in time and space, making some functions more time based and others more spatial. As and example, traditional cameras with a shutter at the lens, do the exposure all at once over the whole area in the same amount of time, while copiers image only a stripe of image at a moment which sweeps out the whole image, spending a different but essentially equal amount of time on each zone of the image. It is also worth considering if you want the hardware equivalent of an army of ants, or an elephant doing the job. Fiber optics does imaging in the army of ants approach, while a single lens uses the elephant approach. The laws of scaling economically are drastically different for the two approaches, and often each has a useful region of application. In this approach the imagination of a child should be linked with the discipline of an adult, so the final version of the idea will really work. Neither quality alone will get through this method.

D. Design and do **conceptual** experiments with clear go or no go conclusions. These should test the key idea decisively. This is NOT high number of significant digits work generally, and should be done as quickly as possible. The apparatus should be more than good enough but unused surfaces do NOT need nice finishing. My tendency to use old coffee cans with labels showing probably expresses excessive contempt for incremental workers who may be needed later.

The above outline was worked out separately and inserted. It does cover this subject tersely.

Refine the portions of the operation space where those proposals which do work, but fail under some conditions is a first step. The operating space usually can be described with a range of inputs or demands. Quite often nominally unacceptable methods will work over part of the demand space. Extensive conceptual testing of the ways the current inventory fails is essential for further work, and should be documented in case there are the usual repeated passes around the iteration loop.

At this step each concept should be checked to see if it can be optimized to move the failure zone out of demand. Occasionally the method of failure can be blocked from happening. Paper handling often is restricted to a range of thickness and size, tissue paper, cardboard, stamp size and engineering drawing sizes are incompatible in any one reasonable cost piece of equipment. Very seldom occurring demand at the edge of operating space can be very expensive, so a cheaper solution which does not do everything is often better. This may have a very significant market for such a solution.

Sometimes a specific patch is possible for a failure mode. These should be look at carefully. The major document copy process in the 1970s had wide exposure tolerance because it could not reproduce large uniform areas correctly. Competitive processes which did reproduce the large areas correctly have to have some sort of exposure adjustment, either manually or automatically. This is fundamentally a patch, since in document copy application most documents are on white stock, and the exposure usually does not need adjustment.

Hybridization of the current inventory of concepts is the first and least exotic of the methods to use. If the alternatives currently evaluated are really in different conceptual field, the failures are often not in different parts of the operating requirements. At this time a very strong investigation of the possibility of using more than one of these approaches at the same time should be done. Really conceptually different approaches often will plug each other’s “holes”, and sometimes act synergistically so that the result is more than would be expected. When the hybrid is first put together quite often there are components from the two original concepts that are redundant. Choosing which of these to eliminate should be done quite carefully. The result usually is a concept that is not significantly more complex in operation than either of the two originals, although the analysis of it may be very interesting.

One of the reasons for preserving the original concepts at this review stage is to have them available for hybridization later, as well as for defensive patent work.

A major problem in the team approach, (sometimes in individual work) is that the different specialties have developed different definitions and symbols. Thus you can have two specialists (or texts) agreeing very sincerely but appearing that they are disagreeing. For the purpose of the project, consistent definitions, and algebraic symbols must be used by all in discussion. When there are different specialties involved make very sure to take care of the gaps between them. Overlapping knowledge to cover the entire information is needed.

Procedure or Software changes with all the alternatives currently available should be thought of at this stage. You should be really prepared to feel very stupid when you find the better way to do it.

This example concerns a stepper motor driven single point film scanner. Stepper motors can be brought up to a higher speed of operation if they are accelerated in stages, instead of just directly brought up to speed. Unfortunately it takes about as many stages of speed to slow them down. Thus if you are controlling such a scanner, you could and would generally start with a routine that got the head up to speed, then stopped it, and then collected the data. A much faster software routine is to bring the head up to full speed, then at each motor compute the matrix element to store the data, grab the data on the fly, and file the matrix at the turn around. This way the motor is going at maximum speed except for direction reversals. This is about 4 times faster than the stop and start method, and because the speed is essentially constant, it does much less vibration damage to the head.

This example concerns a simple electrical shutter. It contained two moving parts suspended by springs, which caused the blades to move by simple harmonic motion like a ballistic galvanometer. After simplifying and reducing the mass to a minimum, the shutter speed was still too slow for the generation of cameras. Although high shutter speeds would be desired only at small openings the usual method of increasing the speed of the shutter by using stiffer springs would not be practical because of the increase in electrical power consumption wide open. To double the shutter speed, four times stiffer springs are needed. This means four times higher current through the motor coils, and 16 times the wattage. This meant melting the motor coil supports at longer shutter times.

The software or drive pattern solution was to use full motor power to accelerate, and decelerate the blades with relatively soft springs. A relative low level of power would be used to hold the blades open. If we were really greedy, it was possible to use the high voltage power from a strobe flash capacitor for the high speed motion. (In these cameras high speed shutters were only anticipated when the flash would be inappropriate.) For small openings, shutter speeds of 1/1000 second were obtained with blade systems that previously only worked for 1/60 second, using the strobe capacitor. This was about 17 times the shutter speed improvement. The instrumentation to automatically determine drive waveforms for hand built shutters without destroying them, using a very early personal computer were quite a challenge.

Special or extreme case solutions need to be investigated. In chemistry, there is a pressure, and temperature combination for most compounds called the triple point, at which liquid and gas become indistinguishable. Quite often extreme solvent power is observed, and some interesting behavior. In mechanics, some periodic structures, and electronics at the resonant frequency some interesting relationships become true. This is even more true with some positive feed back - thus the old super regenerative radio receivers. Springs which have two modes of bending can be used to generate force curves similar to compound bows, by going close to a low tension shape for aiming. Many of these areas of the operational space tend to be ignored because of the difference in mathematics and concept. Any special area of performance can hide an optimum, that if controlled may be an answer.

When the requisite number of alternatives are roughed out proceed back to parallel development stage.

<u>This closes the iteration loop.</u>

Demonstration, and Sales of the Concept.

There are a number of operating rules which I have found essential, which will be discussed first. They boil down to respecting the customer.

The most important thing here is credibility. This is so important professionally that I will discuss it first.

Never claim to know something you do not. Reservations about unconfirmed hypothesis, have been meticulously remembered by everyone I have worked with. Even reasonable estimates of the probability of various consequences have been well handled. Rather paradoxically a very careful admission of ignorance has enhanced my reputation repeatedly. People who claim to know more than they do, are subject to experimental verification or disproof of their claims. Virtually every time a question is asked in a professional context it will be checked in the real world. Knowing the limits of your current knowledge is a major asset because it allows you to work at full capacity with minimal risk.. When you are wrong admit it. I recommend fully tracing down the source of the error. Even primary textbooks in specialized fields have had typographical errors in fundamental equations, which fail dimensional analysis.

Have the statistical error estimates available for all experimental data.

Your customer needs to understand what the concept can do for him, and what it costs to do it. He has to realize that the redefined needs description is valid, and may need a layman's working knowledge of the concept. The part of the concept that is not obvious to those skilled in the art has to be made clear. As a general rule anything that can not be explained in relatively simple language is really not understood well. Thus difficulty in translation to common language is often a warning that something is dangerously wrong with the understanding of the concept. There are some things that do take a Hawking, or Feynman to describe in elegantly simple form.

First of all try to understand the way your customer is most likely going to think. You probably got to the truth about the concept by a route which is entirely foreign to the customer, but from the position of knowing the truth, you can usually trace multiple ways to have approached the truth. This is particularly true when an epiphany (suddenly revealed truth) happened.

Here are some specific approaches that have worked for me.

Sometimes you are demonstrating a single concept, and I am always in favor of making a demonstration, hopefully in a form where the key decision making customer can actually do the demonstration with a little instruction. This can precede the explanation to get full attention. Then lead the customer through the steps to the full understanding of how it works. Answer all questions, and as mentioned above admit what you do not know. If obtaining that knowledge requires an experimental series it is a good idea to have a good estimate of the most probable course of work, and time to completion. Absolute certainty is usually prohibitively expensive.

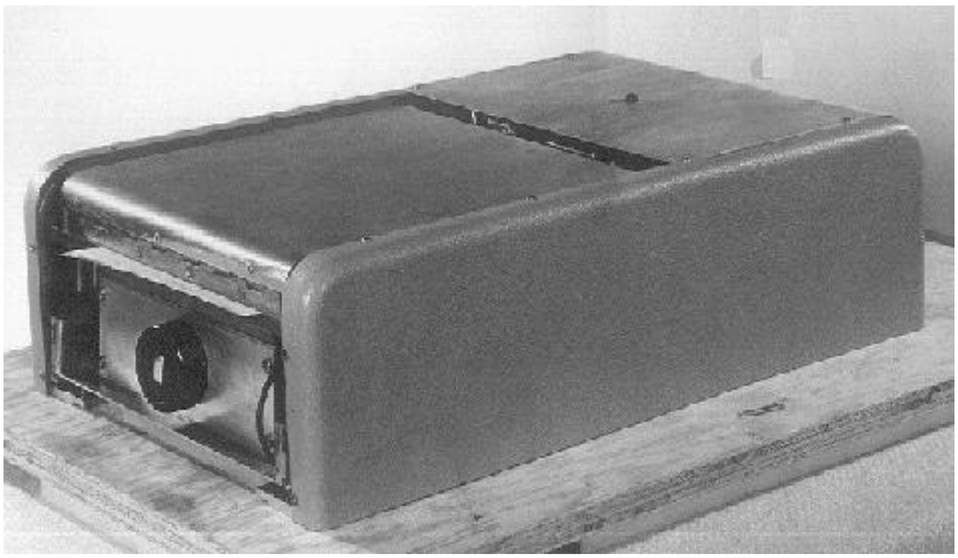
If the key sales work well, you should have several more similar meetings with the people who are going to work with the idea. Although this is call "transfer of technology" it is really the same sort of thing. Quite often once the customer understands what you have done they will pick up the idea and do more with it than possibly could.

Never insult the customer by implying incompetence. If there is real incompetence, you will not have to call attention to it. Your role here is as a teacher, in fact a tutor and helping everyone around any problems of understanding is part of it.

A similar approach is required where a series of inventions have been combined to provide a new synthesis. Each critical concept must be clearly documented, explained and the relationship of these changes to the whole synthesis. This can involve quite a bit of education.

An example of this sort of synthesis is an office copier I designed in 1965. At that time office copiers were very large, expensive, and centralized. The list cost was about ten cents a copy, but that did not count the time for a person (average burden cost $30/hour) to get to and from the copier. When I included that cost I concluded that a very small, crude, copier replacing a desk drawer in each person's desk might be preferable. Because of the labor saving, a considerably higher cost per sheet would be justified.

Innovations were needed in the spacing of processing stations to reduce transport rate, optics to reduce drastically power consumption, geometry of scanning to simplify mechanics, and in the image fixing station so that it was essentially instantly on. Relatively minor improvements in Xerographic charging and toning were also needed and developed. All of these were fairly tightly related and needed to make the copier work. This was done before I realized that I was following a systematic approach, which somewhat hindered work, and complicated the explanations.



This was considered significantly revolutionary, so that it was awarded a special security classification. Although the photosensitive material eventually could not be competitively produced by Kodak, and the design never was manufactured, many of the small copiers now sold have similar basic components in them.

The champion for sales of a concept can be someone quite different from the inventor. As mentioned before, I devised a method for neutralization of static charge on insulator surfaces for my own utility and had absolutely no idea other people had the same problem. The champion for the idea was Carl Gibbons (the name is not changed because heroes need rewarding) who ran with the idea. This increased some film coating rates 5 times, was essential in Kodak Xerographic copiers, and facilitated dust removal for early CD recording experiments. In this case the synergistic combination of an excellent honest salesman, and the inventor was remarkable.

There is also a cat's paw method of selling an idea when time is not available for the originator to develop it. In this case all credit for the idea will be given to a person who may lack only the creativity to truly originate the idea. After the conceptual work is well in hand, but not recorded officially tutor the patsy very cautiously leading them by the concept by many paths, but not telling them the concept. When eventually they discover the relationships, be slightly effusive with praise and a subtly guiding as possible. Do express your regret that you are too busy to follow this fascinating idea. They get the patent and the credit for something you would really not have had the time to develop and deserve it. If you get caught in the act there is the risk of developing a cadre of followers trying to sweep up your intellectual crumbs.

One of the things to avoid is a hostile presentation. Sometimes the invention process will proceed from personal reasons when not at all assigned or requested. A really clean solution to a problem can make the inventor feel very superior, and is artistically pleasing. I have been guilty of then limiting the presentation to three times, and doing it so low key the probable user has no awareness that the answer was presented.

Patent Work.

Protection of the intellectual capital generated by this effort is important.

Notebooks should be filled out regularly. The current rules for form of entry, and proving that the entry is in the notebook in unaltered form must be determined. During my time at Kodak, a bound notebook, not loose leaf was required. Items pasted into the notebook were to be done with rubber cement, and a wavy line with an ink type pen zigzag across the edge used to show these were not altered later. Each page to must be dated and signed by the inventor, and the inventor's signature identified by the word inventor. The page also had to be witnessed by someone who could potentially testify in court without conflict of interest, and understand enough of what was described to remember it convincingly. This disqualifies all joint inventors, and those who would substantially profit from the possible patent. In an industrial laboratory someone working on a separate problem was easy to find. Working single alone this is a rather hard to accomplish. The date of conception for patent work is the date the notebook page on which the conception was recorded is witnessed. The earliest date of conception theoretically gets the patent if due diligence for practical realization of the patent was demonstrated.

In preparing a patent application make sure that all people who contributed to the conceptual evolution of the concept and no more people are included as inventors. Normally technicians who do things only under direction are not included. However I did have a technician develop a very well described needs description for an invention, but he lacked the scientific training to finish the idea. He came to me for that extra work to realize the invention, which was a single alternative design. He had really done most of the critical work defining the need for the device very tightly, and so I considered that I was more the joint inventor. It took considerable effort to keep him on the patent because of heavy prejudice on the part of professionals with doctorate degrees, but it did issue with George Alley as an inventor.

Getting a good patent is time consuming, not likely to succeed, and expensive. The group average on patenting is about 10% to completion. About 10% of those that get patented see some marketing. My average of success in getting patents is far better than the average, but the marketing is a bit worse.

First of all you will need a good patent agent. There has to be a very good trust between the inventor and the patent agent. This is a penny wise / pound foolish thing. Kodak provided excellent staff for this.

The legally required language in patents claims is only vaguely related to normal English. Each claim must describe the whole concept and the incremental part covered by that claim in a single sentence. These sentences are usually longer than the length of the paragraph above starting with "In preparing". The claims are what protect your intellectual property and are really what you are paying for. I really do NOT think this is a field for amateurs.

The first section of the report discloses the practice of the invention so that it can be understood "by those skilled in the art". Hypothetically if these are not operational instructions the patent can be thrown out of court.

Once a draft is in hand, a search of the prior art is required. To get the patent you will have to certify that no one has done this ever before. If as was the case with a well known copier company, your intent is just to cloud up the whole intellectual property field, a minimal search can be done, with the idea of putting the burden of proving each of these cheap patents invalid on the competition. If you really plan to use the patent, then you really need to make sure that no one will suddenly appear following a lawyer claiming you have infringed his patent. Incidentally, any improvements on a previous unexpired patent need a license to be useful.   Good searches used to cost about $5000, and may be about that today because of computerized searching available over the net.

The fee to the government is an insignificant part of the patent expense.

It used to take years for patents to issue.

Finally, a repeating inventor is probably the worst person around to determine if an idea is sufficiently unobvious to be patented.   Additional skills are accumulated each time the process is finished, some of which are not widely known. These skills eventually make the inventor able to easily deduce relationships most of his colleges will miss. You can easily arrive at the point where it is very difficult to understand what other people can not do. Problems that you will consider simple engineering may be completely mysterious to others. The only solution I know to that problem is a good management team to work with, and let someone else decide what is unobvious.

Conclusion

Selling and patenting the invention concludes the invention portion of development of the idea.

The systematic iterative procedure described provides a very high yield way to generate inventions.   The full procedure is not fully justified for some things which are conceptually easy. The training with "live ammunition" by use of this method generally increases skills quite appreciably, and later in the profession allows use of sections of the process to solve relatively simple problems.

I hope you find this useful, financially rewarding, and great fun. I did!!

Appendix 1, My list of Patents

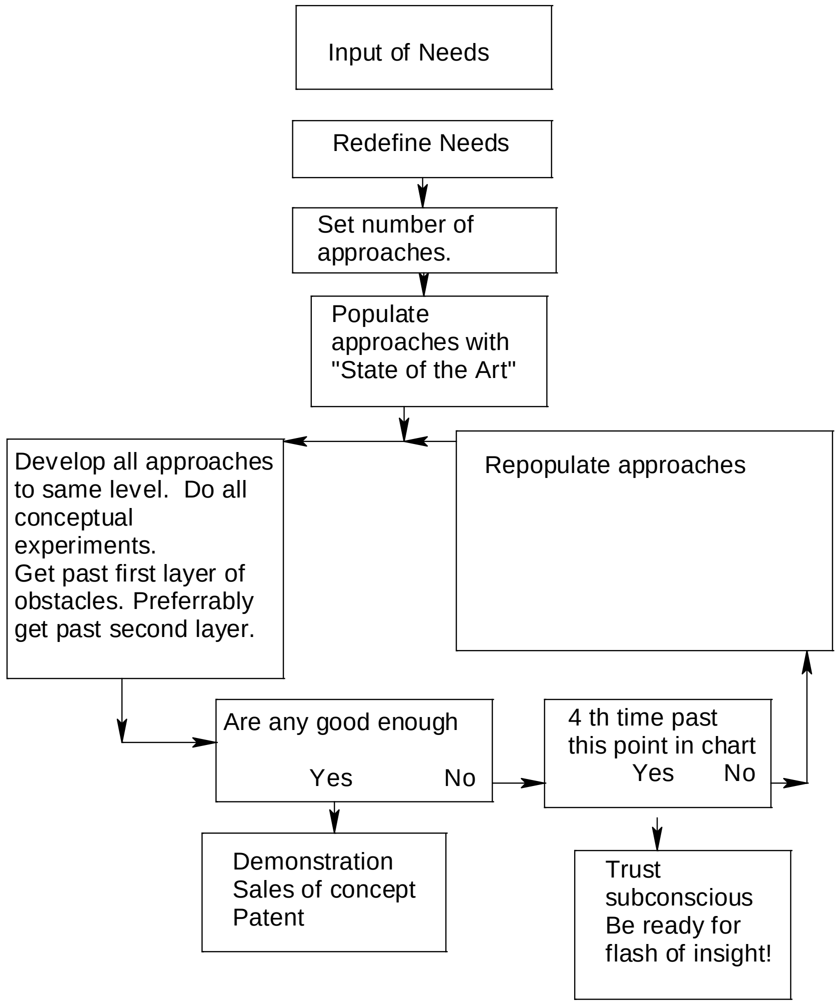
	Number	Date	Name of Patent
1	6,113,288	9/5/2000	Water Deposition apparatus and method
2	5,579,072	11/26/1996	Film drying apparatus with uniform flow air tubes
3	5,481,327	1/2/1996	Film drying apparatus with uniform flow air tubes
4	5,411,650	5/2/1995	Captive vortex high agitation device
5	5,379,087	1/3/1995	Processing apparatus
6	5,315,338	5/24/1994	Apparatus for enhancing heat and mass transfer in a fluid medium
7	5,294,955	3/15/1994	Apparatus and method for washing light sensitive material
8	5,289,224	2/24/1994	Processing apparatus
9	5,239,327	8/24/1994	Processor for light sensitive material
10	5,181,329	1/26/1993	Drying apparatus
11	5,172,153	12/15/1992	Processing apparatus
12	5,150,955	9/29/1992	Drying apparatus
13	5,136,323	8/4/1992	Apparatus for enhancing heat and mass transfer in a fluid medium
14	5,084,911	1/28/1992	X-ray phototimer
15	5,064,259	11/12/1991	Apparatus for scanning a photo-stimulable phosphor sheet
16	4,989,028	1/24/1991	Apparatus for processing light sensitive material
17	4,750,014	6/7/1988	Optical device
18	4,594,614	6/10/1986	Film video player with electronic strobe light
19	4,490,037	12/25/1984	Image sensor and rangefinder device having background subtraction with bridge network
20	4,490,027	12/25/1984	Magnetically encoded film containers and camera adjusting

			mechanisms responsive thereto
21	4,423,934	1/3/1984	Photographic camera with digital controller and method of manufacture
22	4,408,857	10/11/1983	Method and circuit for controlling an electromagnetic actuator in photographic apparatus
23	4,291,958	9/29/1981	Camera with electronic flash and piezoelectric lens motor
24	4,258,993	3/31/1980	Light discrimination apparatus
25	4,198,140	4/15/1980	Piezoelectric camera shutter
26	4,190,336	2/26/1980	Piezoelectric power supply for cameras
27	4,162,832	7/31/1979	Exposure control with piezoelectric latch control
28	4,125,319	11/14/1978	Active light control device
29	4,119,979	10/10/1978	Timed piezoelectric shutter control for cameras
30	4,104,657	8/1/1978	Piezoelectric electronic shutter control for cameras
31	4,072,411	2/7/1978	Display device having image sense reversal capability
32	4,057,337	11/8/1977	Compact viewer
33	4,047,031	9/6/1977	Apparatus for obtaining radiographs
34	3,981,566	9/21/1976	Lever-action mountings for beam steerer mirrors
35	3,932,809	1/13/1976	Deflector galvanometer
36	3,881,921	5/6/1975	Electrographic Process employing Image and Control Grid Means
37	3,714,442	1/30/1973	Exposure control Circuitry
38	3,698,100	10/17/1972	Operator Responsive Programmed Learning Apparatus
39	3,694,800	9/26/1972	Acoustical Gauge (quality control for film position in 110, 128 cartridges)
40	3,680,954	8/1/1972	Electrography
41	3,660,656	5/2/1972	Light Locked Corona Device
42	3,659,348	5/2/1972	Apparatus for Fusing Xerographic Toners
43	3,638,016	1/25/1972	Self Biasing Grid Control Corona System
44	3,611,414	10/5/1971	Electrographic Oscillograph
45	3,536,434	10/27/1970	Efficient Optical System
46	T869,009	12/31/1969	Double hardening Epoxy for precision castings
47	3,451,752	6/24/1969	Compact Document Copier
48	3,443,089	5/13/1969	V-Grooved Optical System
49	3,409,354	11/5/1968	Optical Systems with Axial Mirrors
50	3,370,212	2/20/1968	Corona Charging System
51	3,264,933	8/9/1966	Cylindrical Lens and Laminated Plate Scanning System
52	3,241,438	3/22/1966	Cylindrical Lens Scanning System
53	3,232,201	2/1/1966	Fiber Optical Scanning System

Non Patented work.

Reversal Transfer Process #8 for instant color film single solution ektachrome process
Analysis method and tool for residual silver in processed film 100Xfaster & more precise
Epcot Stereo Movie standards Sharpness, and strand matching to avoid audience vertigo
Eyeglasses for mobile robot to improve navigation to useful level
Photospace computer program for evaluation of automatic camera systems. (Advantix)
Finished glass lens molding oxygen problem identification
Charge Neutralizer for film which allowed 5 x increase in productivity of some color film coaters

Appendix 2 The flow chart.


Input of Needs
Redefine Needs
Set number of approaches.
Populate approaches with "State of the Art"
Develop all approaches to same level. Do all conceptual experiments.
Get past first layer of obstacles. Preferrably get past second layer.
Repopulate approaches
Are any good enough
Yes
No
4 th time past this point in chart
Yes
No
Demonstration
Sales of concept
Patent
Trust subconscious
Be ready for flash of insight!